NUTRITION

A GUIDE TO FOOD AND DIETING

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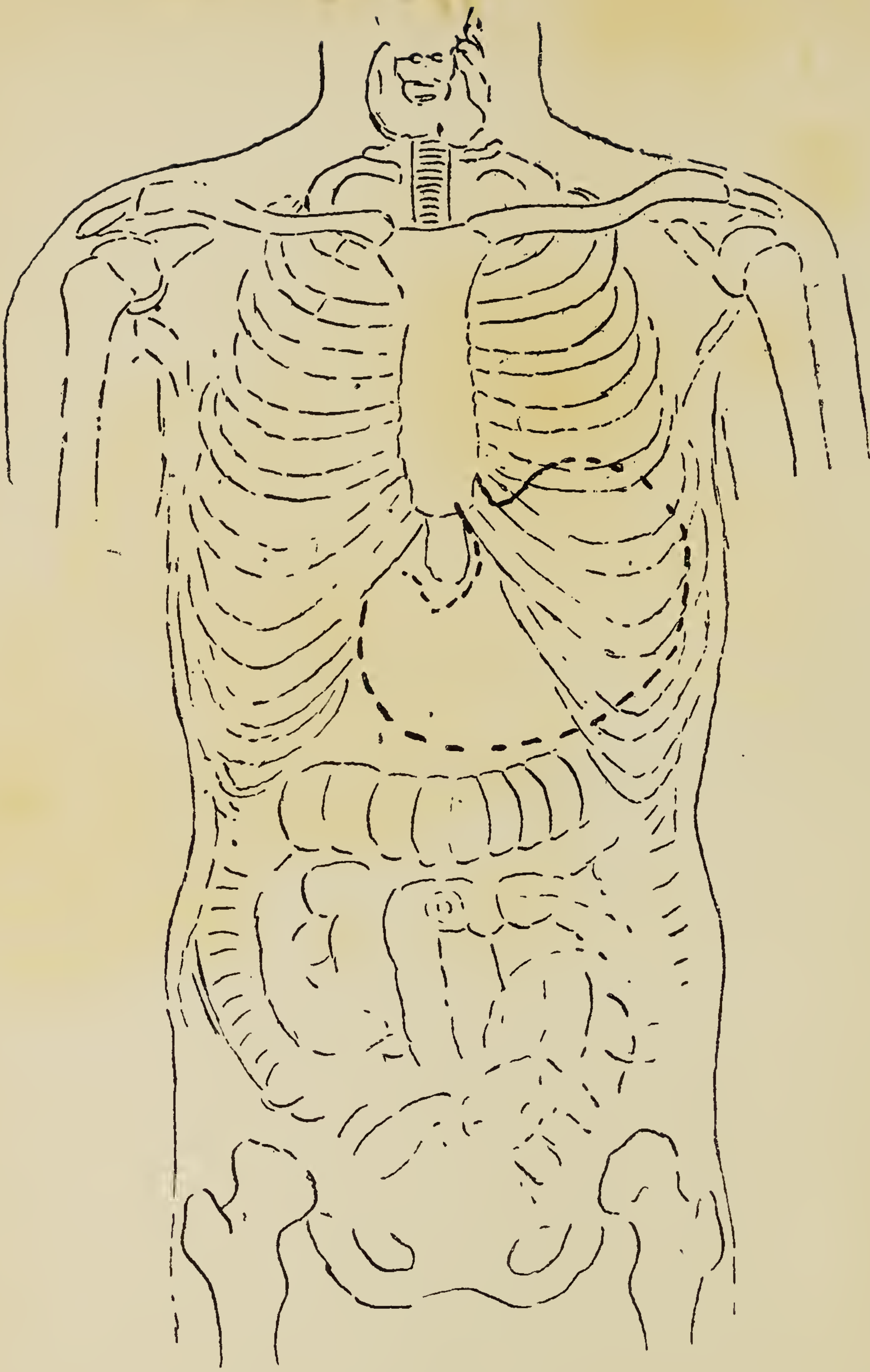

Fig. 3.

Normal Position of Stomach (dotted line). (After Ranney.)

NUTRITION

A GUIDE TO FOOD AND DIETING

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WITH 7 ILLUSTRATIONS

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PREFACE

In health we receive the axioms of the dietician with apathy, if not contempt, laughing at all 'systems' and pursuing our way regardless of what the future may have in store for us; and yet but a little consideration will show how regrettable are the consequences of this attitude and how widespread.

Not only is an immense amount of suffering and disease traceable to non-observance of the laws governing alimentation, respiration and exercise (the last two being inseparably linked with the former), but a still more vast aggregate of discomforts, minor ailments, weakened vitality and lowered efficiency—mental and bodily—are directly due to the same causes.

It is calculated that there are in the United Kingdom at least EIGHT MILLION persons suffering from dyspepsia in some shape or form. How many more must there be who are habitually afflicted with sick headaches, biliousness, gout and rheumatism? And these are to a large extent self-inflicted punishments!

The magnitude of infantile mortality, too, a large proportion indisputably the result of improper feeding, is still a blot on our civilisation, notwithstanding recent improvements. One child out of every five is

lost—one might say sacrificed—before it attains its fifth year; while among the poor in certain districts the awful ratio of one in two is reached.

In his mental activity, physical 'fitness,' power of resistance to disease and relative immunity therefrom, the properly nourished individual affords a striking contrast to the badly fed person. With the latter, lassitude and depression are normal characteristics, coughs and colds rarely leave him; his impaired digestion engenders irritability, perhaps hallucinations, mental and physical occupations become increasingly difficult, and consumption and other diseases find in him a happy hunting-ground. He is, in a word, a misery to himself and a danger to the community.

He who, far from spurning, desires to study scientific nutrition, finds himself dragged hither and thither by conflicting doctrines expounded by sincere but obsessed philosophers. Successively he is told that his only hope is to be found in lentils, that his health demands pea-nuts, that nothing but repeated meals of boiled haricots can save him, that purine bases must be avoided at all costs, that common salt spells death, or that if he will but chew long enough he can very nearly dispense with food altogether and will greatly benefit thereby. He has, too, to resist the appeals of the seductive advertisement—not necessarily concocted by the manufacturer of the article advertised, but by a 'specialist' whose business is that of composing 'telling lines.' He hears, for instance, that a little two-ounce bottle of the Uncontrollable Meat Company's

Essence contains all the nutriment of many stones' weight of beef, and that X's Cocoa is Nature's Ideal Food and a teaspoonful of it will sustain him for half a day, that Y's Oats are the only brain food, and so on.

He is not safe among writers who are not advertisers in the ordinary sense, for we have known them to discourse quite eloquently upon the nutrient value of proprietary foods of which they did not know the composition!

In the following unpretending little treatise, which aims at presenting the subject of foods in a simple form for ready reference, we have avoided theory and bias as far as possible, endeavouring to collate facts only. We trust it may serve as an introduction to a study that means so much for the health and vigour of the human race.

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CHAPTER I

GENERAL PRINCIPLES

Although the complexity of an organism like the human body is such that the patient labours of all the world's investigators have as yet far from completely unravelled the whole of the mysteries of its wonderfully intricate and delicate structures or the half of the multifarious physiological and chemical processes proceeding within them, yet—fortunately—there is no difficulty in comprehending the main principles upon which living depends.

Life may be defined as a condition of restless change, in which every cell of the organism takes part, the protoplasm of the cell and the oxygen of the air being the governing factors.

It is an unceasing building up and breaking down, or a continual replenishment of losses wrought by a species of slow combustion.

The chemical life functions of a human being are strictly analogous with those of other animals, and until our race exhibits a tendency to develop chlorophyll—that remarkable compound which enables vegetable organisms to construct their tissues from

mineral matter, carbonic acid, water and ammonia—we must supply our bodies at certain intervals with ready formed food principles to renew the tissues that are wasting and restore the reserve of energy which is being dissipated every moment of our lives.

Health can only be maintained when the amount of these losses is exactly counterbalanced by the food assimilated and the oxygen absorbed.

The intakings and the outgoings must be equal.

Our flesh is slowly burning; for whether food be first converted into tissue or directly utilised as fuel, its fate in either case is to be consumed by oxygen drawn in by the lungs. This gas, carried by the blood stream into the most intimate contact with every particle of our bodies, enters into chemical combination with products derived from foods and from the tissues themselves, the energy evolved during these chemical changes serving to provide force for muscular exertion and heat for maintaining the body temperature.

Every heart-beat, every breath, in fact every voluntary and involuntary movement—every thought even—necessitates energy, the sum total of which can be exactly determined; for the relationship in which heat and work stand to each other is known with mathematical certainty, and the heat or force value of any kind of food can be calculated with no less precision.

We can measure, too, the rate at which our tissues are wasting and deduce the kind and quantity of aliment competent to balance the loss, so that although there may be disturbing factors in our calculations, such as those proceeding from idiosyncrasies in special cases, the science of dietetics rests upon a sound basis.

CALCULATIONS SIMPLIFIED

As the grain is an absurdly small unit when dealing with foods, and very few of us remember (unless we have only just left school) how many there are in an ounce, the grain has been dismissed from these pages altogether. We cannot ignore the ounce and pound in the same way, although it would save much trouble if that were done.

The ounce is rather too large a unit for exactitude, but the gramme on the other hand is particularly convenient for our purpose; it has therefore been adopted generally, the equivalent or approximate equivalent in ounces being also given. For instance, the figures for the normal dietary (see Chap. VI) are easily recollected when expressed in grammes, thus :—

Fat . . .	50 grammes	(about	$1\frac{3}{4}$ oz.).
Protein . . .	100 ,,	,,	$3\frac{1}{2}$,,
Starch or its equivalent	400 ,,	,,	14 ,,

The best way to enable one to think in grammes is to use them in weighing, but if this be inconvenient all that is necessary is to bear in mind the following relationships :—

1 oz. is roughly 28 grammes.
4 oz. is a sort of miniature 'cwt.' in grammes, i.e. 112 grammes.

(this is not absolutely correct, but sufficiently so for practical purposes ; 1 oz. is really 28·3 grm. and 4 oz.= 113·2 grm., 1 lb.=453 grm.).

To save unnecessary calculations conversion tables are provided of gramme and ounce equivalents, also one showing what any percentage of a pound weight actually means in ounces and grammes.

YIELD PER POUND AT EACH PERCENTAGE

%	Yield in oz.	Yield in grm.	%	Yield in oz.	Yield in grm.	%	Yield in oz.	Yield in grm.	%	Yield in oz.	Yield in grm.
1	1/6 nly.	4·5	26	4 1/6	117·8	51	8 1/6	231	76	12 1/6	344·3
2	1/3 ,,	9	27	4 1/3	122·3	52	8 1/3	235·6	77	12 1/3	348·8
3	1/2 ,,	13·6	28	4 1/2	126·8	53	8 1/2	240·1	78	12 1/2	353·3
4	2/3	18·1	29	4 2/3	131·4	54	8 2/3	244·6	79	12 2/3	357·9
5	4/5	22·6	30	4 4/5	135·9	55	8 4/5	249·1	80	12 4/5	362·4
6	1 nly.	27·2	31	5 nly.	140·4	56	9 nly.	253·7	81	13 nly.	366·9
7	1 1/8	31·7	32	5 1/8	145	57	9 1/8	258·2	82	13 1/8	371·5
8	1 3/10	36·2	33	5 3/10	149·5	58	9 1/3	262·7	83	13 1/4	376
9	1 1/2	40·8	34	5 4/9	154	59	9 4/9	267·3	84	13 4/9	380·5
10	1 3/5	45·3	35	5 3/5	158·5	60	9 3/5	271·8	85	13 3/5	385
11	1 3/4	49·8	36	5 3/4	163·1	61	9 3/4	276·3	86	13 3/4	389·6
12	1 9/10	54·4	37	5 9/10	167·6	62	9 9/10	280·9	87	13 9/10	394·1
13	2 1/10	58·9	38	6 1/10	172·1	63	10 1/12	285·4	88	14 1/10	398·6
14	2 1/4	63·4	39	6 1/4	176·7	64	10 1/4	289·9	89	14 1/4	403·2
15	2 2/5	67·9	40	6 2/5	181·2	65	10 2/5	294·4	90	14 2/5	407·7
16	2 1/2	72·5	41	6 5/9	185·7	66	10 5/9	299	91	14 5/9	412·2
17	2 3/4	77	42	6 3/4	190·2	67	10 3/4	303·5	92	14 9/10	416·8
18	2 9/10	81·5	43	6 9/10	194·8	68	10 8/9	308	93	14 8/9	421·3
19	3	86·1	44	7	199·3	69	11	312·6	94	15	425·8
20	3 1/5	90·6	45	7 1/5	203·8	70	11 1/5	317·1	95	15 1/5	430·3
21	3 1/3	95·1	46	7 1/3	208·4	71	11 1/3	321·6	96	15 1/3	434·9
22	3 1/2	99·6	47	7 3/5	212·9	72	11 1/2	326·2	97	15 1/2	439·4
23	3 2/3	104·2	48	7 2/3	217·4	73	11 2/3	330·7	98	15 2/3	443·9
24	3 17/20	108·7	49	7 4/5	222	74	11 5/6	335·2	99	15 5/6	448·5
25	4	113·2	50	8	226·5	75	12	339·7	100	16	453

Conversion of Grammes into Ounces

Grm.	Oz.	Grm.	Oz.	Grm.	Oz.	Grm.	Oz.	Grm.	Oz.
1	0·03	26	0·91	51	1·80	76	2·68	125	4·41
2	0·07	27	0·95	52	1·83	77	2·71	150	5·30
3	0·11	28	0·99	53	1·87	78	2·75	175	6·18
4	0·14	29	1·02	54	1·90	79	2·79	200	7·05
5	0·18	30	1·06	55	1·94	80	2·82	250	8·82
6	0·21	31	1·09	56	1·97	81	2·85	300	10·58
7	0·25	32	1·13	57	2·01	82	2·89	350	12·34
8	0·28	33	1·16	58	2·04	83	2·93	400	14·11
9	0·32	34	1·20	59	2·08	84	2·96	450	15·87
10	0·35	35	1·23	60	2·11	85	3·00	453·6	16·00
11	0·39	36	1·27	61	2·15	86	3·03	500	17·64
12	0·42	37	1·30	62	2·18	87	3·07	600	21·16
13	0·45	38	1·34	63	2·22	88	3·10	700	24·69
14	0·49	39	1·37	64	2·26	89	3·14	800	28·22
15	0·53	40	1·41	65	2·29	90	3·17	900	30·75
16	0·56	41	1·44	66	2·33	91	3·21	1000	35·33
17	0·60	42	1·48	67	2·36	92	3·24		
18	0·63	43	1·51	68	2·40	93	3·28		
19	0·67	44	1·55	69	2·43	94	3·31		
20	0·70	45	1·59	70	2·47	95	3·35		
21	0·74	46	1·62	71	2·50	96	3·38		
22	0·77	47	1·65	72	2·54	97	3·42		
23	0·81	48	1·69	73	2·57	98	3·46		
24	0·84	49	1·73	74	2·61	99	3·49		
25	0·88	50	1·75	75	2·64	100	3·53		

CHAPTER II

THE HUMAN BODY STRUCTURALLY REGARDED, CHIEFLY WITH RESPECT TO THE DIGESTIVE SYSTEM

In this chapter we shall direct our attention more especially to the alimentary system, passing lightly over structures whose relationship thereto is but indirect. By the aid of the diagrams we hope it will be possible for the reader to form a clear picture of the relative positions of the various organs concerned in food assimilation.

The alimentary canal.—The mouth, pharynx, gullet, stomach and intestines together form the alimentary canal, which it is important to remember is a single continuous conduit, a sort of main line without branches; hence ALL NUTRIENTS IN ORDER TO BE ABSORBED MUST PASS THROUGH THE WALLS OF THE TUBE ITSELF, and for this to be possible they must be reduced to a solution, or in the case of fats to an extremely fine emulsion.

The *mouth.*—In regard to the mouth we have first to consider *the teeth,* each of which consists of a hollow, bony case having a 'crown' projecting above the gum, and below, one or more roots or 'fangs' imbedded in a socket (alveolus) of the jawbone, although not a direct outgrowth from the bone.

There are, or should be, in the adult, 32 teeth, as follows :—

8 incisors—thin cutting teeth, 4 in the front of each jaw ;
4 canine or ' eye ' teeth, with pointed ends, designed for gripping or tearing ; these are adjacent to the incisors ;
20 molars ; teeth with more or less broad tops ; those next to the canine teeth having two ' cusps ' or points in the crown (bicuspid) ; those farther back having four cusps. The molars are for grinding the food.

The tongue.—A highly muscular organ, capable of a wonderful variety of movements, and bearing over its surface a great number of ' taste bulbs ' or papillæ. These are ' filiform '—delicate thread-like ' fungiform '—somewhat mushroom - shaped, or ' circumvallate '—constructed like the last but with a kind of wall round each. The last, being larger than the others, are readily distinguished, being arranged in a V-shaped row towards the root of the tongue.

The salivary glands.—Besides a number of small glands which contribute to the supply of saliva to the mouth, there are six large glands which provide the greater bulk of that fluid, viz. :—

The *parotid glands*, one on each side, in the flesh of the cheek near the ear, their ducts opening into the mouth at points opposite the second molar tooth of the upper jaw, counting from the back forwards ;

The *sublingual*—under the tongue ; and

The *submaxillary* glands, two of each; the latter, a little farther back than the former, occupy positions between the lower jaw and the floor of the mouth.

The fauces.—At the entry to the throat is to be seen depending from the soft palate (velum), in the centre, a soft, fleshy protuberance, the uvula; on either side of it, the tonsils—small oval glands which secrete mucus to lubricate the fauces during the passage of food—and below, the epiglottis, a sort of

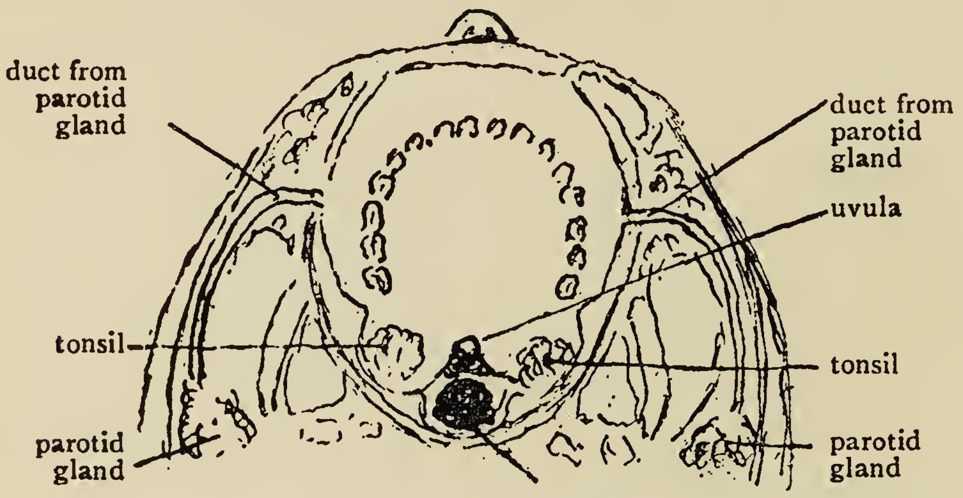


FIG. 1.
SECTION SHOWING UPPER JAW. *Seen from below.* (After Roser.)

gristly lid which bridges over the windpipe (trachea) when food or drink is on its way to the gullet (œsophagus), which lies just beyond. The back of the tongue, the uvula, the soft palate and the epiglottis, meeting together, form a kind of partition behind which is a cavity—the pharynx—into which there are six openings: below, the windpipe and gullet already alluded to, and above, the two nasal passages and the eustachian tubes from the ears, these latter tubes being found, one on each side, in line with the nostril, a little above and behind the uvula (see Fig. 1).

The œsophagus, or gullet, is a tube some 9 inches in length, having muscular walls lined with epithelium (the delicate skin which covers all the interior cavities of the body). It lies between the windpipe and the vertebral column, or backbone. In its descent to the stomach, with which and the pharynx it forms the

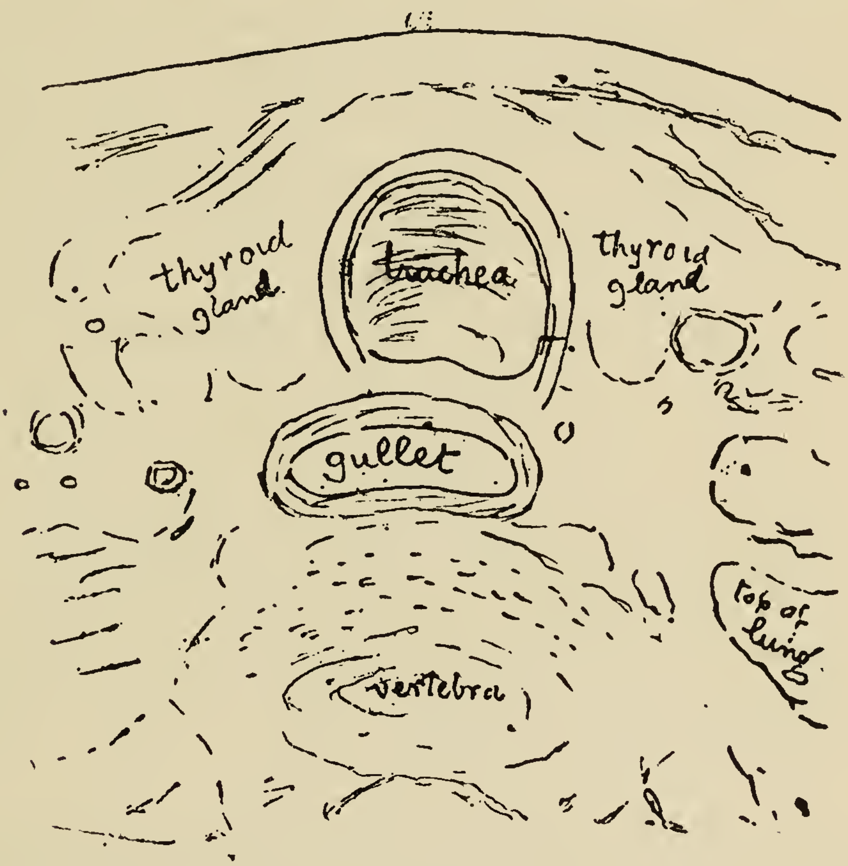


FIG. 2.

SECTION THROUGH NECK AT POINT BELOW FIRST DORSAL VERTEBRA. *Seen from above.* (After Braune.)

connecting link, the gullet bears very slightly to the left (Fig. 2).

The stomach.—If we imagine a tube, originally U-shaped, but which has been greatly expanded on the outer side of the U, and much more on one arm than the other, we shall get a rough idea of the shape of the stomach when moderately charged. It lies across the body with the greater expansion turned to the

left; the œsophagus entering it above by the cardiac orifice, nearly in the centre; the exit, closed by the pylorus, being also above, but on a lower level than the œsophagus, and at the small end, on the right side.

It, the stomach, lies almost wholly to the left of the middle line of the body, in part covered by some of the lower left ribs. The liver projects over its right side, the pancreas is behind it and the spleen on its left, while beneath is the horizontal portion of the colon (Fig. 3).

Like other organs of the abdomen, the stomach is liable to considerable alteration of position, depending on its own degree of distension, the extent of inflation of the lungs, and the varying contents of the viscera. When over-distended the stomach causes displacement of these, and may impede the action of the lungs and heart. Conversely, its own functions may be hampered and its place disturbed by other organs—an abnormally large liver for example.

The interior coating of the stomach is beset with innumerable small glands which secrete digestive fluids when food is present.

The intestines.—Leaving the stomach by the pylorus, food has to pass successively through the duodenum, jejunum and ileum, which together form the small intestines, and the cæcum, colon, and rectum, which constitute the large intestines.

The duodenum—so named because it is supposed to be 12 finger-breadths in length—is horse-shoe shaped and bent back upon the stomach; its first part is movable like the stomach, which it joins, but the remaining portion is fixed to the body-wall. The bile and pancreas discharge their very important digestive secretions into the duodenum.

The jejunum and ileum. No natural line of demarcation separates these, the terms being respectively applied to the first and last portions of the small intestines below the duodenum. On the other hand, the termination of the ileum and the commencement of the cæcum are sharply defined; the narrow ileum entering not the end but the side of the much broader cæcum; this latter terminates in one direction in a blind alley (cæcus=blind) bearing a prolongation called the vermiform appendix; in the opposite direction is the colon.

A valve—the ileo-cæcal valve—placed at the junction of the ileum and cæcum, prevents reflex of intestinal matters.

The large intestines.—The coils of the small intestines lie deeper in the abdomen than is the case with the large intestines, which to some extent covers them. Thus the colon, rising perpendicularly from the cæcum at the lower right side of the body, proceeding then horizontally to a position beneath the stomach, and again turning downwards to join the rectum, rests throughout most of its length quite close to the front surface of the body.

Many transverse folds, termed *valvulæ conniventes*, characterise the small intestines and increase its effective area, while the larger intestine has a peculiar system of muscular bands which give it a puckered appearance.

Both the large and small intestines are capable of what is known as peristaltic movement, a series of contractions, having the effect of driving their contents forward.

The interior coating of the intestines is provided with numerous glands secreting intestinal juice; also enormous numbers of minute thread-like projections called villi (singular, *villus*, a hair) whose duty is to absorb the nutritive principles of the food passing before them.

Data:—

Mouth	
Pharynx . . .	about $4\frac{1}{2}$ inches long.
Œsophagus . . .	9 to 10 ,, ,,
Stomach, capacity about .	about 6 pints.
The small intestines:—	
Duodenum . . .	about 9 inches long.
Jejunum and Ileum .	,, 20 feet long.
The large intestines:—	
Cæcum and colon .	,, 4 ,, ,,
Rectum . . .	,, 8 inches long.

How nutrients pass from the stomach and intestines to the general system.—Every intestinal villus has its own artery, capillary network and vein, also lacteal vessels intertwined therewith. The artery brings fresh blood almost directly from the aorta or main artery; this blood after traversing the capillary network, returns by the vein, carrying with it such nutrients from the intestine as have passed by osmosis[1] through the walls of the villi and those of the capillary blood vessels; all this blood, as well as that from the stomach, is gathered up by vessels leading into the portal vein (vena portæ), which distributes it to the liver; after mingling with the blood which flows through the immense number of capillaries in that organ, it is eventually conveyed to the heart, there to be pumped all over the body.

[1] Passage of a dissolved substance through a membrane.

Fat takes a different route; for, unlike the other food principles, it is not actually dissolved in the intestine but emulsified, in which condition it is apparently unable to penetrate the walls of blood capillaries. It does, however, get through the epithelium of the villi, and passing in the form of microscopic globules into the lacteals gives to their contents the milky appearance to which they owe their name. Thence the fat pursues a circuitous course until, on reaching the thoracic duct—the trunk line of the lymphatic system—it is discharged by the latter into the blood stream.

RESPIRATORY AND VASCULAR SYSTEMS

Although we are chiefly concerned with the alimentary tract, we cannot omit a brief reference to the vascular and respiratory systems—so indissolubly associated with it.

The alimentary system provides fuel and building material; the respiratory apparatus supplies oxygen to burn up both the fuel and, later, the tissues that have been built; the vascular system constitutes the means of distribution of oxygen in one direction to the tissues, and of carbonic acid, etc., in the other direction from them.

From the nose or mouth, air enters the windpipe (trachea), which has two main branches, one leading to each lung; these, by division and subdivision an enormous number of times, finally terminate in little sacs—alveoli—of which there are several hundred millions. Intertwined with these there is a similarly intricate network of minute blood vessels.

Just as there is no direct opening from the alimentary

tract into the body, so it is with the blood and air vessels; neither system has any opening into the other. Exchange of contents takes place by diffusion through the walls of the vessels.

Combustion, formerly thought to be confined to the lungs, is now known to be carried on in the tissues of the body generally.

Living laboratories.—The body includes several organs partaking of the nature of chemical laboratories or factories, such as the liver, pancreas, kidneys, etc., in which a multitude of physiological and chemical operations are carried on, but an attempt to describe these would lead us too far into the domain of physiological chemistry.

CHAPTER III

THE HUMAN BODY—CHEMICALLY CONSIDERED

IF a human body were submitted to chemical analysis in a very crude manner, without separating the individual compounds but only the water from the solids and these into broad groups, the result would be :—

Water	55 to 71 per cent.
Mineral salts	7 ,, 9 ,, ,,
Protein and other nitrogenous organic substances	16 ,, 21 ,, ,,
Fat and other non-nitrogenous organic substances . . .	5 ,, 15 ,, ,,

If the analysis were of a more destructive character, every compound being reduced to its chemical elements, we should find :—

Non-metallic elements (in descending order of quantity) : Oxygen, Carbon, Hydrogen, Nitrogen, Phosphorus, Sulphur, Chlorine, Fluorine, Silicon.

Metallic elements (also in descending order) : Calcium, Potassium, Sodium, Magnesium, Iron and small traces of others, such as Manganese, Copper, Lithium, Lead, Arsenic, etc.

Water.—The fluids of the body are all extremely aqueous, and the tissues so thoroughly permeated by liquid that they may be said to be bathed in water ; thus :—

Percentage of Water in Body Fluids and Tissues.

Saliva	about $99\frac{1}{2}$ per cent.
Gastric juice	about $99\frac{1}{2}$,, ,,
Sweat	98 to $99\frac{1}{2}$,, ,,
Aqueous humour of eye	about 98 ,, ,,
Blood	,, 79 ,, ,,
Muscles	70 to 75 ,, ,,
Brain and nerves generally	64 ,, 84 ,, ,,
Bones	10 ,, 30 ,, ,,[1]

The least watery parts of our structure are the dental enamel, nails and hair.

In addition to what is contained in the food and drink consumed, a certain quantity of water is formed within us by combustion, as we shall see later on (see Chapter on 'Digestion').

Mineral salts.—Throughout every one of our organs, tissues and fluids, mineral salts are distributed in a proportion which—if we except the teeth and bones, which are very rich in these matters—may be taken to be roughly about one per cent., or more correctly seven to eighteen parts in a thousand.

Mineral Matter in various Human Tissues, Fluids, etc.[2]

Dental enamel	96·4 per cent.
Dentine	96·3 ,, ,,
Bone	66·7 ,, ,,
Muscle	1·8 ,, ,,
Nerve	1·7 ,, ,,
Urine (24 hours)	1·3 ,, ,,
Blood plasma	0·8 ,, ,,
Blood corpuscles	0·7 ,, ,,
Pus	0·8 ,, ,,
Lymph	0·7 ,, ,,
Bile	0·8 ,, ,,
Gastric juice	0·24 ,, ,,
Saliva	0·2 ,, ,,

[1] Ranges up to 50 per cent.

[2] *Vide* Ralfe, "Clinical Chemistry."

Although the mineral portion of any tissue or fluid is always a mixture of a number of salts, certain mineral salts are found to preponderate in certain situations. In the bones, for instance, calcium phosphate far outweighs the others; in the flesh, potassium phosphate takes the lead; while in all the fluids (except the milk) sodium chloride (common salt) is greatly in excess of other mineral compounds.

In the following lists the salts are named in order of importance in the respective tissue or fluid:—

BONES.—Calcium phosphate, calcium carbonate, magnesium phosphate, calcium fluoride.

BRAIN.—Potassium phosphate, sodium phosphate, sodium chloride, with smaller quantities of magnesia and lime salts.

LIVER.—Potassium phosphate, sodium phosphate; the following in smaller amount: Calcium phosphate, potassium and sodium chlorides, iron salts, sulphates, silica.

THE LUNGS AND SPLEEN are peculiar in that they contain a great preponderance of sodium over potassium salts. The spleen is remarkable too in containing a relatively large amount of iron.

BLOOD.—Sodium chloride, potassium phosphate, iron; further: phosphates, sulphates, carbonates of soda, potash, lime and magnesia.

MILK.—Potassium and calcium phosphates, potassium and sodium chlorides and smaller quantities of magnesium and iron compounds.

Protein.—Life is mysteriously and indissolubly linked with certain nitrogen-containing compounds termed proteids—or in general protein. Many of the

lower animals exist without a skeleton, and there are vegetables having neither chlorophyll nor cellulose; but in all vegetable and animal organisms, from the lowest to the highest, protein is ever present; in fact LIFE IS A CONDITION OF CHANGING PROTEIN. The simplest form of living matter is a small mass of protein, a speck of protoplasm, undergoing constant metamorphoses. Of all forms of matter, it alone possesses the incomprehensible power of converting dead compounds into living substance and reproducing life like its own—in other words, the power of growth, which is the essence of life.

In all higher forms of life this vital principle—protoplasm—(from *protos*, first, and *plasma*, formed or moulded) is enclosed within a protecting wall, forming a cell, and with the exception of microbes and such fungi as the yeast plant, in which the whole organism consists of but a single cell, all organised beings, even the most highly specialised—man—are merely aggregations of cells.

In vegetables the cell wall is non-nitrogenous, but in all animals it is, like its protoplasmic contents, of a proteid character.

Percentage of Protein in Human Tissues and Fluids.[1]

Crystalline lens (eye)	38·3	per cent.
Arteries, tunica media of	27·3	" "
Muscle	16·2	" "
Liver	11·6	" "
Brain	8·6	" "
Spinal cord	7·5	" "
Blood	8·5	" "
Chyle	4·0	" "
Milk	3·9	" "
Lymph	2·5	" "

[1] As found by Gorup Besanez.

Complexity of proteids.—Proteids are probably the most complex chemical compounds in nature, and their molecules, holding as they do numerous atomic groupings, are huge when compared with those of the majority of substances, thus :—

Relative weight of molecule of			Hydrogen . .	2
,,	,,	,,	Water . .	18
,,	,,	,,	Alcohol . .	46
,,	,,	,,	Sugar . .	342
,,	,,	,,	Albumin, a typical proteid, between	14,000 & 15,000

Most other classes of compounds have given way under the attacks of the research chemist, but the proteids, in consequence of their exceptional complexity and peculiar physical characters, have proved the most difficult field of investigation in the whole domain of organic chemistry. If this be so with dead matter, how much more distant must be the prospect of solving the mysteries surrounding the ever-changing protoplasm ?

Characteristics of proteids.—Proteids exhibit a very extended range of properties, from the horn-like keratin of our finger nails to albumin of egg white. Some dissolve in cold water, others only on heating. Albumin which is soluble in the cold is thrown out on warming ; globulins require an addition of salt to effect solution ; others, again, are totally insoluble in water, whether pure or saline, hot or cold, and not easily brought into solution by more drastic treatment. But with all these variations they have general features in common.

All contain carbon, hydrogen, oxygen and nitrogen,

and generally sulphur, sometimes phosphorus also. They are, with rare exceptions, colloids, i.e., glue-like, non-crystalline bodies which, even in solution, cannot pass through animal membranes, or in other words are non-dialysable, a property of physiological significance.

When subjected to elementary analysis the composition of different proteids is found to vary within the following general limits :—

Carbon . .	from	about	51·5	to	54·5	per	cent.
Hydrogen . .	,,	,,	3·9	,,	7·3	,,	,,
Oxgyen . .	,,	,,	20·9	,,	23·5	,,	,,
Nitrogen . .	,,	,,	15·2	,,	17·0	,,	,,
Sulphur . .	,,	,,	0·5	,,	2·0	,,	,,

Detailed differentiation of the proteids would only be of interest to chemists, but short definitions of the more prominent classes of these compounds will help our comprehension of such physiological chemistry as is unavoidable to a simple exposition of the phenomena of digestion.

In the following résumé the terms employed are those most commonly used, but it is necessary to warn the reader that the nomenclature of this branch of chemistry is not yet fixed, the same word being occasionally used by different writers in different senses. For instance, the word *albuminoid* may be applied either as synonymous with proteid, covering the whole group, or to one division only. The term *albuminate,* too, which some writers have applied to all proteids, is in the more modern chemical literature restricted to quite a small and comparatively unimportant sub-class.

CLASSIFICATION OF NITROGENOUS ORGANIC SUBSTANCES FOUND IN THE HUMAN BODY

1. **Proteids** properly so called :—

(*a*) ALBUMINS.—Soluble in cold water, but coagulated on heating ; then no longer dissolved by water hot or cold. Coagulated albumins are rendered soluble in the stomachs of man and animals by peptase (see below), being changed at the same time into albumoses and peptones.

White of egg is a solution of albumin. Serum-albumin contained in blood and lact-albumin in milk are other examples. Albumins are disseminated in small quantity throughout the body, the amount being estimated roughly at one per cent.

(*b*) GLOBULINS.—Closely resemble albumins ; not soluble, however, in water alone, but in weak solutions of salts.

Like albumins, they are widely distributed ; there are globulins in blood (serum-globulin), in muscle (myosin), in the eye (crystallin), in egg yolk (egg globulin), etc.

(*c*) ALBUMOSES and PEPTONES.—These are, as stated above, the products of the action of the digestive secretions upon albumins and other proteids. They are soluble in water.

(*d*) COAGULATED PROTEIDS.—The spontaneous clotting of blood on exposure to air is due to the formation of fibrin, a coagulated proteid derived from fibrinogen. Coagulated albumins

have already been referred to. In the insoluble portions of flesh other forms are met with. Some of these compounds undergo solution when acted upon by enzymes (which see).

(*e*) ALBUMINATES, in the restricted sense, are compounds formed from albumins by the action of acids (acid albumin) or alkalies (alkali albumin). They are not of great interest here.

2. **Compound proteids.**—These, the most highly complex, include also the most vitally indispensable of nitrogenous substances. To this class belong :—

(*f*) COLOURED PROTEIDS, the chief of which is *hæmoglobin*, the colouring matter of the red corpuscles ; a compound of protein with a pigment which contains iron. By its power of forming a loose combination with oxygen from the air which enters the lungs, and giving up this oxygen again in the course of its journeys through the body, hæmoglobin in the blood stream permits of those oxidising, purifying and vivifying processes without which life would at once cease.

(*g*) NUCLEINS.—The nucleus, that vital spot which is found in every cell of every living thing, contains as characteristic constituents certain compound proteids termed nucleins, which differ from any proteids yet considered in that they are phosphorus compounds. They consist either wholly of nucleic acid—a phosporised nitrogenous acid—or a combination of such an acid (for several nucleic acids are known) with a proteid and one or more

xanthine bases, of which we shall presently speak.

The composition of a true nuclein is therefore nucleic acid plus proteid plus xanthine base.

When the proportion of proteid is very large, that of the nucleic acid small, and the xanthine base absent altogether, the substance is called a NUCLEO-PROTEID.

Nucleins and nucleo-proteids are the most abundant proteid materials obtainable from the nuclei and protoplasm of cells. [Halliburton.]

Milk contains the nucleo-proteid caseinogen which appears as casein in milk curd and cheese.

(*h*) MUCINS are viscous proteids that form slimy solutions, valuable as lubricants in the digestive canal. Food before leaving the mouth is covered with such a mucous secretion in order that it may glide easily down the throat.

Mucins on decomposition with dilute acids yield sugar.

(*i*) MUCOIDS, or MUCINOIDS, closely resemble mucins.

(*j*) PHOSPHO-GLUCO-PROTEIDS are chemically intermediate between nucleins and mucins; like the latter, they contain a sugar group, and in company with the former are phosphorised and yield nucleic acid.

3. **Albumoids,** or **Albuminoids,** in the restricted sense, include what may be described as the distant

members of the proteid family. The principal varieties found in the human body are :—

Collagen, the glue-forming substance of which the white fibres of connective tissue and the proteid portion of bone are constructed. On boiling with water it produces gelatin or glue.

Elastin, the material of which the yellow fibres of connective tissue are made.

Keratin, the horny matter of finger nails, hair and skin. (It is also the basis of the wool, hoofs and horns of animals.)

4. **Enzymes,** or **Zymases,** are ferments which possess the power of inducing chemical change in certain substances with which they may be brought into contact under particular conditions without themselves suffering a permanent alteration. Unlike the living ferments, such as yeast, which is a living organism, they are soluble, unorganised chemical substances, believed to be proteid-like in character, but in regard to the composition of which we are as yet in nearly complete ignorance.

It is in great measure by means of enzymes that food principles are converted into forms adaptable to the body needs, and their power of influencing transformations in quantities of matter enormously greater than their own weight is always remarkable, and in some cases little short of miraculous. As an instance, Delezenne describes an enzyme, detected by him in the intestine, which has the property of exciting pancreatic action even when present to the extent of only one part in one hundred million parts of fluid. He names it *enterokinase.*

Properly speaking, this body is not itself a zymase but a liberator of an enzyme; compounds having these functions are called HORMONES, and to this class belongs *adrenalin,* that wonderful substance from the suprarenal capsules which governs the blood pressure on the veins and arteries.

If the composition of adrenalin is typical of 'hormones,' generally these substances are not proteids, although probably derived from them, for adrenalin can be artificially made and has a relatively simple molecular structure.

We shall only allude to one or two of the principal human enzymes here. Many vegetable enzymes are known, e.g., Diastase in malt, which converts starch into malt sugar and dextrin; Synaptase, or Emulsin, found in bitter almonds, which liberates prussic acid from the glucosidal compound amygdalin present in the kernels.

PTYALIN, secreted by the salivary glands, converts starch into sugars.

PEPTASE, or pepsin, found in the stomach (commercial pepsin is generally from the pig), transforms albumin, whether coagulated or not, and other proteids into substances termed proteoses and peptones (see paragraph (*c*) above). It requires for its action that there shall be a small quantity of hydrochloric acid present.

TRYPSIN, or pancreatin, secreted by the pancreas or sweetbread, decomposes these proteoses and peptones still further, yielding tyrosin, leucin, indol and other intestinal substances. It requires a slightly alkaline medium.

Lipase, also found in pancreatic fluid, breaks up fats into glycerine and fatty acids such as oleic, palmitic and stearic acids.

5. **Non-proteid nitrogenous substances.**—In the breaking down of proteid food and tissue proteid the complex albuminous molecule undergoes a series of splitting and oxidising processes, with the result that substances simpler and simpler in constitution are successively formed until, when the final stages are reached at which the completely utilised materials leave the system, nothing is left (should these metabolic changes be really completed, which is not always the case) but carbonic acid, water and urea, together with small amounts of sulphates and phosphates.

Even if the present state of our knowledge permitted, it would be beyond the scope of this work to describe the innumerable compounds that represent the intermediate steps in these phenomena; and as a few which possess special interest on account of their influence upon health will be more conveniently considered in the chapter upon 'Digestion,' we shall pass over these substances altogether in this section.

NON-NITROGENOUS SUBSTANCES

1. **Fats.**—The physical properties of fats and oils are too well known to need description; it will be sufficient to say that all fatty substances used in food or which are found in the body are glycerine compounds or, in chemical parlance, glycerides of certain fatty acids, the chief of which are:—

Butyric acid, $C_4H_8O_2$, a non-oily liquid of disagreeable odour, soluble in water. It is a characteristic constituent of butter;

Oleic acid, $C_{18}H_{34}O_2$, an oily liquid;
Palmitic acid, $C_{16}H_{32}O_2$; and
Stearic acid, $C_{18}H_{36}O_2$, both white crystalline solids.

The last three are the common components of nearly all animal and vegetable oils and fats, in which they exist as compounds of glycerine in the proportion of three molecules of acid plus one molecule of glycerine minus three molecules of water.

Fat in Human Blood and certain organs, etc.

	per cent. of whole fluid.
Blood, infant . . .	0·007 to 0·057
,, adult . . .	0·050 ,, 0·300
	per cent. of dry matters.
Heart	13 to 17
,, diseased . . .	up ,, 59 has been found.
Liver	13 ,, 17
,, in fatty degeneration .	up ,, 34
,, in alcoholisis . .	up ,, 47
,, in tuberculosis . .	up ,, 56
Kidney	19 ,, 23
,, in pernicious anæmia .	up ,, 34

	per cent. of whole organ.
Marrow	95
Adipose tissue (' fat ') . .	83
Nerves	22
Brain	8
Hair	4[1]

GLYCERINE or GLYCEROL, $C_3H_8O_3$, or $C_3H_5(OH_3)$, the thick viscous sweet and colourless fluid with which we are all familiar, a component of fats and a product of fermentation, is also found in the free state in minute quantities in animal fluids, besides entering into the composition of an important constituent of brain and nerve called :—

[1] Compare Virchow's Archives, 174, also Gorup Besanez.

Lecithin, a molecular combination of glycerine, phosphoric and stearic acids, with a nitrogenous base *choline.* Lecithin belongs to the 'lipoids,' or fat-like bodies (see article on "Eggs").

2. **Carbohydrates.**—In this group of compounds, which comprises starches, sugars and gums, the elements of which they are composed, viz. carbon, hydrogen and oxygen, are so balanced that if all the carbon were removed, the residual hydrogen and oxygen would be in the right proportion to form water; hence they are carbon hydrates.

Starch, the reserve material of the vegetable kingdom, will be dealt with under vegetable foods; it exists only temporarily in the human body, for that which is ingested with the food very soon undergoes transformation.

Glycogen, produced in animal organisms, bears a remarkable resemblance to starch in many respects. Both are reserve materials, glycogen being stored in the liver and muscles. Both are readily converted into sugar, and they have the same percentage composition.

It would appear that when fuel is needed by the system for the production of heat or muscular energy and no other source of supply is available glycogen is drawn upon.

Sugars.—We shall only consider two of these carbohydrates, namely dextrose and inosite.

Dextrose is, in small quantities, an invariable ingredient of the blood of healthy human beings, and in the case of diabetic persons may be

present to an abnormal extent in the kidney secretion.

INOSITE has the same empiric formula ($C_6H_{12}O_6$) as dextrose; it is found in many of the tissues—muscle, liver, nerves, kidney, etc.

GUMS.—Animal gums are an unimportant class, of which little is known. Vegetable gums will be referred to under vegetable foods.

CHAPTER IV

CLASSIFICATION OF THE CONSTITUENTS OF FOODS AND THEIR DISTRIBUTION

JUST as an artist by skilful blending of a few colours may produce an endless variety of hues, so from a relatively small number of food principles does Nature construct that immense range of foods which man has now at command. And as the human being is entirely built up from the food he consumes—transformed though it be by a complex series of chemical and physiological changes—it is not surprising to find that these food principles belong to the same great classes as the substances of which the body itself is composed, namely, PROTEIDS, MINERAL SALTS, WATER, FATS and CARBOHYDRATES.

From a strictly theoretical point of view protein, water and mineral salts are the only essential food principles, for it is possible to build up all our tissues and organs and to secure all the necessary vital energy from these; but practically such a diet would be inexpedient, if only for questions of taste and cost. We find it more convenient and agreeable—also less expensive as well as less provocative of metabolic fatigue—to allocate to protein, as far as practicable, its special rôle of building material, and to depend for physiological 'fuel' less upon protein than upon carbohydrates (starches and sugars) and fats. (This subject will be further dealt with in Chap. VI.)

Food principles may be classified as follows :—

INORGANIC SUBSTANCES :—

Water.
Mineral salts.

ORGANIC SUBSTANCES :—

(1) Essentially tissue-building :
Proteids (nitrogenous compounds such as albumin).

(2) Essentially energy-supplying :
Carbohydrates (starches, sugars, gums).
Fats and oils.
Gelatin—nitrogenous, like proteids, but unlike them, not tissue-building.

In addition to these, which may be said to be the only true food principles, there exist in our food a number of compounds which, though perhaps not all indispensable, may act beneficially as flavourings, stimulants to digestion, and so on ; these are termed food adjuncts and comprise bases such as caffeine, essential oils, organic acids, alcohols, etc.

As we have already touched upon the chemical compounds of the body human, and since these run parallel with those of foods, we have here only to supplement the remarks made in Chapter III, to which we refer the reader for descriptions of proteids, carbohydrates, etc.

Water, as will be seen on comparing the several tables, enters in varying amount into the composition of every food, and is the basis of every beverage, being the only fluid capable of assuaging thirst ; the ideal and only solvent adapted to the needs of the body. (Drinking water is dealt with in Chap. XVII.)

Amount of Water in Foods.—In the following list foods and drinks are arranged in order of their humidity, commencing with the driest :—

Sugar (nearly free from water), confectionery, arrowroot and other starches, dry peas and beans, wheat flour and other cereal products, butter (9 to 16 per cent.), pastry (varies greatly), bread (35 to 42), cheese (30 to 50), spirits (40 to 60), raw meats and poultry (60 to 75), eggs (72 to 76), fish (70 to 80), potatoes (average 75), green vegetables and fruits (73 to 92), wines (80 to 92), milk (average 86 to 87), beer (87 to 93), mineral waters (nearly wholly water).

Oxygen, of which we require a greater weight than of all solid foods together, may be regarded as a food —and is so treated by Abderhalden—since it forms part of every food as well as of every substance in our bodies, but oxygen occupies an altogether exceptional position ; it stands quite alone in its bearing upon life. We may replace one food by another within certain limits, but there is nothing in the whole range of elements that can replace oxygen, a constant, abundant and an uncontaminated supply being a *sine qua non* of existence.

Mineral salts exist in nearly all our foods, although generally in quite small amount, the rough, general average being one per cent. Here are a few examples:—

Flesh foods, meat, fish or fowl, 0·8 to 1·8 per cent., milk (cows') 0·7 to 0·75 (average), vegetables and fruits 0·5 to 2, wheaten flour 0·4 to 2·4, bread average about 1, oatmeal 1·5 to 4, butter 1 to 3, cheese 3 to 5, spices 3 to 8, meat extracts (often containing much added salt) up to 25 per cent.

This mineral matter consists chiefly of potash, soda, lime and magnesia in the form of phosphates, chlorides and sulphates, besides iron, manganese, silica, etc., in traces. The importance of these compounds will be discussed in Chapter V, but we would point out here the desirability of remembering that the several salts needed by our body are in many foods not evenly balanced, so that some are over-rich in one and deficient in another salt. Of this fact the following table affords illustrations :—

Meats . .	rich in phosphate of potash	—
Egg (yolk) .	rich in lime phosphate and iron	. poor in potash and soda salts.
Egg (white)	rich in potash and soda salts	. poor in phosphates.
Milk, human	rich in lime	. poor in iron.
„ cows'	ditto	. ditto
Wheat . . .	. .	. poor in lime and soda salts.
Rice . . .	. .	. poor in potash (relatively).
Potato . .	rich in potash	. poor in soda salts.
Vegetables generally	rich in potash	. poor in soda salts.

Carbohydrates (compare also Chap. II). Of this group the members which we meet most commonly in foods are the following :—

Cellulose, characteristic of the vegetable world, not being found in animal tissue ; forms the cell wall of all vegetable structures and on ageing is converted into lignin or woody fibre. Blotting paper is nearly pure cellulose.

Not being assimilated by man, except perhaps

in very small quantities when it is in a very young and tender condition, cellulose cannot be regarded as a food principle.

Proportion of cellulose and woody fibre in foods.—Wheaten flour, high quality, a mere trace; lower grade flour, 1 per cent.; wheat, whole grain, 1·2 to 6·4; oatmeal, 0·8 to 2·5; green vegetables as eaten, i.e. stalks removed, 0·7 to 3; wheat bran, 6 to 8; oats, whole grain, 7 to 12; fruits (fresh), including kernel, 0·9 to 12 per cent.

STARCH, like cellulose, is exclusively vegetable in origin; both, too, have a visible structure; but while cellulose is fibrous, starch occurs in the form of microscopic grains, the form and markings of which vary with the botanical origin.

Formed during daylight in the green parts of plants, starch does not long remain there, being either used up for the current needs of the vegetable organism or conveyed to the root or fruit and stored there.

Unlike cellulose, starch is, after cooking, readily digested both by adults and children, with the exception of very young infants, and constitutes one of the most important of the food principles. In fact it is the one of which we habitually consume the most.

Foods arranged in increasing order of starchiness.—Meats and all natural animal foods, nil; green vegetables and fruits, starch generally absent; potatoes, 18 to 25 per cent.; wheaten bread, 40 to 60; oat, whole grain, 45 to 60; barley, 50 to 65; maize, 50 to 70; peas and beans, dried, 55 to 65; rice, 70 to 80;

pastry, a large proportion (varies greatly); arrowroot, sago, tapioca, cornflour, 75 to 86 per cent.

Sugars (see also special chapter on 'Sugar'). A large number of sugars are known to chemists, but we need only consider those of dietetical importance; these are the following :—

Cane or beet sugar—of which the chemical name is saccharose—is so well known that a description would be superfluous. Although commercial table sugar is nearly wholly derived from beetroot or sugar cane, saccharose is widely distributed in the vegetable kingdom, generally associated with two other sugars—dextrose and lævulose—into which it may be readily converted.

Dextrose or grape sugar, and *lævulose* or fruit sugar are found together in sweet fruits and honey, in the product called *glucose* obtained by boiling starch with dilute sulphuric acid, in the similar preparation termed invert sugar obtained by like treatment of cane sugar, and in small amount in grain and cereal foods.

Dextrose, as stated on page 28, Chapter II, is invariably an ingredient of the blood, but generally forms but a very minute proportion of the solid matter in that fluid. In the disease known as diabetes mellitus it occurs in the urine in abnormal quantities.

Maltose or malt sugar is formed from starch by the diastase of malt, and is produced in large amount during the 'mashing' process of brewing.

Lactose or milk sugar is the sugar found in the milk of all the mammalia, including the human race. It forms hard and not very sweet crystals when deposited from concentrated milk serum.

Sugars become broken down during fermentation by yeast into alcohol and carbonic acid.

Fats were shortly described when treating of the constituents of the human body; it will be sufficient to give here a general table upon the amount of fat or oil found in various foods, the importance of fat as a component of diet being referred to in Chapter VI.

Foods with little or no fat.—Cornflour, arrowroot, tapioca, sago, potatoes, green vegetables, fruits (mere traces of fat).

Foods with but little fat.—Wheaten flour and bread, pea, bean, lentil and banana meals, chestnuts. These foods contain generally from 0·5 to 2 per cent.

Hare, venison, pigeon, partridge (usually under 2 per cent).

Foods with moderate proportions of fat.—Lean meats, rabbit, fowl, eggs, oatmeal (up to 10 or 12 per cent. of fat).

Foods with large proportions of fat.—Fat meats, goose, almonds, cocoa nibs, dried milk, etc.

Foods nearly wholly fat.—Butter (77 to 90 per cent.), lard, marrow, etc.

Gelatin, although belonging to what may be termed an outlying branch of the proteid family, has to be treated separately, for an important reason, namely, that, unlike the true proteids, it cannot be converted into living tissue; it may, however, serve as do the carbohydrates in supplying energy, and it has a special function—a tissue-sparing power—rendering it valuable in febrile and other pathological conditions in which the digestive system is too enfeebled to permit of the administration of true proteid food;

in such circumstances the excessive wasting of the tissues is retarded by beef-tea, which is a decoction containing gelatin, meat salts and stimulating xanthine bases, but devoid of true flesh-formers.

Gelatin or glue, the former name being applied to the purest forms of glue (the chemical differences between the two being but slight), is formed whenever animal tissues are boiled, particularly tendons, sinews, skins and bones, and it is from such materials that the commercial article is obtained.

The PROTEIDS proper have, so far as those occurring in the human body are concerned, received treatment in Chapter II; those found in animal flesh are strictly analogous with human proteids, while those of the vegetable kingdom are less similar but agree with them on broad general lines.

PROPORTION OF PROTEIN IN FOODS:—

Foods containing but insignificant amounts of protein.—Prepared starches (tapioca, arrowroot, etc.), many fruits.

Foods with usually less than 3 per cent.—Green vegetables, potatoes, and roots such as carrots, turnips, onions, etc.

Foods with moderate amounts of protein.—Milk average 3½ (a low percentage but nevertheless a high ratio of protein to non-protein); fresh peas, beans and lentils (3 to 8), white bread (6 or 7), fine wheat flour, barley (8 to 10 or 12).

Foods rich in protein.—Oatmeal (10 to 15), eggs (12), fat meat (12 to 18), lean meat, also dried peas, beans and lentils (18 to 25), cheese (25 to 35).

Casein and various artificial products (see special protein foods) may contain as much as 85 per cent.

CHAPTER V

DIGESTION—ASSIMILATION—METABOLISM—RESPIRATION

HAVING in earlier chapters outlined the structural and chemical aspects of the human alimentary system and the character of food principles, we are now in a position to trace what takes place during the processes connoted by the terms digestion, assimilation and metabolism.

Definitions.—By *digestion* we understand the preparatory steps by which the food is brought to a state in which it may be absorbed. *Assimilation* is the process of incorporation or absorption ; and *metabolism* the changes involved in the building up into living substance and the subsequent breaking down into waste products. (Some writers restrict the word 'metabolism' to the building-up stages and employ the term 'catabolism' for the later decompositions.)

Food in the mouth.—The preliminary stage of digestion may begin before the food actually reaches the mouth, for the very sight of it, particularly if pleasing to the eye and nose, causes the issue of orders from the brain in response to which the salivary glands commence to pour out their secretion into the mouth. This has a twofold object: firstly to thoroughly moisten the food —for a large proportion of fluid is absolutely essential;

and secondly to mix with the material that is being masticated some of the digestive enzyme ptyalin that has the power of converting starch into sugar. (There are traces of other ferments in the mouth, but they are of smaller importance.) During mastication this flow of saliva is increased, the amount being adjusted to the dryness of the food.

A neglected truism.—It is a truism, but one that cannot be too often reiterated, that ADEQUATE MASTICATION ENORMOUSLY FACILITATES DIGESTION (a fact that should be written large on the walls of every dining-room), and we may show its truth in this way: Solution is an unavoidable prelude to digestion; now the rate at which a solid dissolves in a fluid depends (among other things) upon the solid's surface area. Suppose we drop a one-inch cube of sugar candy—the hard, solid, non-porous form of sugar—into a pint of water; it might take half an hour to dissolve because there are only 6 square inches of surface exposed to the solvent action of the water. If, however, such a lump were broken into 100 smaller pieces the surface exposed would be 10,000 times more than in the case of the single lump, and as a consequence solution would be completed 10,000 times as quickly! In digestion the case for comminution is far stronger, for we are dealing there not with simple solution but with the chemical conversion of insoluble into soluble substances—a much more difficult process.

Use of hard dry food.—It is probable that much modern dyspepsia arises from our having lost the habit of chewing hard dry foods which *had to be* so well masticated that the salivary glands were kept active and the teeth clean.

The food on its way to the stomach.—Having been moistened and incorporated with saliva, broken up by the teeth and shaped by the tongue into an oval-shaped mass or bolus, the mouthful is lubricated by the secretion from the tonsils and conducted over the glottis to the œsophagus or food pipe by successive muscular expansions and contractions which propel it downwards to the stomach.

The food in the stomach.—Just as the salivary glands in the mouth are excited to activity by the presence of food, so are the peptic glands of the stomach on the entry of food into that organ.

Following a nervous impulse, the small arteries dilate, an increased blood supply arrives and the glands commence secreting drops of gastric juice containing the ferment pepsin and weak hydrochloric acid. The muscles begin a rolling motion, and under the twofold action—chemical and mechanical—the contents of the stomach are eventually reduced to a creamy condition.

A very widespread misconception prevails in regard to the absorptive powers of the stomach. Very little absorption takes place through the gastric walls. Some sugar, alcohol, and other fluid and a small proportion of nitrogenous matter is taken up, but neither starch nor fat, for these are not acted upon by the gastric secretions, and leave the organ chemically unaltered. Protein does undergo peptonisation, as we know, but that does not change it sufficiently; the much more severe treatment encountered later in the journey through the duodenum and small intestines is needed to break down these food principles to the requisite degree.

Absorption of nutrients is the special work of the intestines, and occupies but a subordinate place among

the duties of the stomach, which is often sadly wanting too in its more legitimate rôle of grinding mill and peptoniser. In fact, a consideration of these failings coupled with a knowledge of the far superior secretory as well as absorptive powers of the intestines has so impressed certain physiologists as to lead them to express the opinion that the organ might, without a great deal of inconvenience, be dispensed with.

Although this may be an extreme and scarcely justifiable belief, it will nevertheless serve to correct the tendency towards over-estimating the stomach's digestive actions.

Discharge from the stomach.—The time during which food remains in the stomach depends upon the degree of activity of the gastric secretion, the nature of the food, and the automatic opening and closing of the pyloric valve. For long an explanation of the latter phenomenon was sought in vain, and even now is not thoroughly understood ; we have learnt, however, that acidity plays the chief part. Acid, which is only secreted at the cardiac end of the stomach, gradually spreads, as the food becomes incorporated with it, towards the pylorus ; when a certain acidity at that end has developed, the valve opens and chyle is discharged into the duodenum, but on encountering the alkalinity of that organ, again closes. [See Halliburton : 'Annual Report of the Progress of Chemistry,' 1907, 229].

In a word, acidity opens and alkalinity closes the valve.

For this reason, the addition of alkali to a food will prolong its retention by the stomach, while acid will hasten its expulsion.

Food changes in the intestines.—The most energetic

ferments to be found anywhere in the alimentary tract are without doubt those with which the food-stuffs are mingled when on leaving the stomach they enter the duodenum. Here we find enzymes capable of dealing with each of the alimentary principles—protein, carbohydrates and fats—all of which are reduced to that simplicity of chemical constitution which is an essential prelude to incorporation in the literal sense.

The extent to which proteins have to be broken down was not suspected until quite recently. The mere splitting into peptone—formerly thought to suffice—is now known to be altogether inadequate. We have learned from researches but lately completed that the complex protein molecule has to be quite crushed into a heterogeneous assemblage of fragments, from which those suitable for building up into body protein are selected for that purpose, the remainder being utilised as fuel, i.e., as a source of energy.

In the case of the other food principles—carbohydrates and fats—the chemical changes are far simpler. The starch molecule is resolved into a certain number of molecules of sugar, the latter directly absorbable. Fats are either emulsified and (so far as we at present know) conveyed to the lacteals in that form, or converted into glycerine and fatty acids, part being changed into soaps.

Soluble mineral salts may be absorbed as such, but the best condition for the presentation of iron, lime and magnesia compounds would seem to be chemical combinations with organic matter, such that coagulation of tissue protein is prevented.

Principles of absorption.—*The whole object of the digestive processes is to render food-stuffs diffusible*, for

no nutriment can be assimilated until reduced to a state in which it can pass through a cell membrane. Hence the conversion of starch—insoluble and indiffusible—to sugar, which is readily diffusible, and the drastic breaking down of the relatively large protein molecule, which cannot penetrate a cell wall, to simple amido compounds, which have that power.

The comparative sizes of a protein molecule and of one of the chemical fragments to which it is reduced by the intestinal ferments are represented by the two

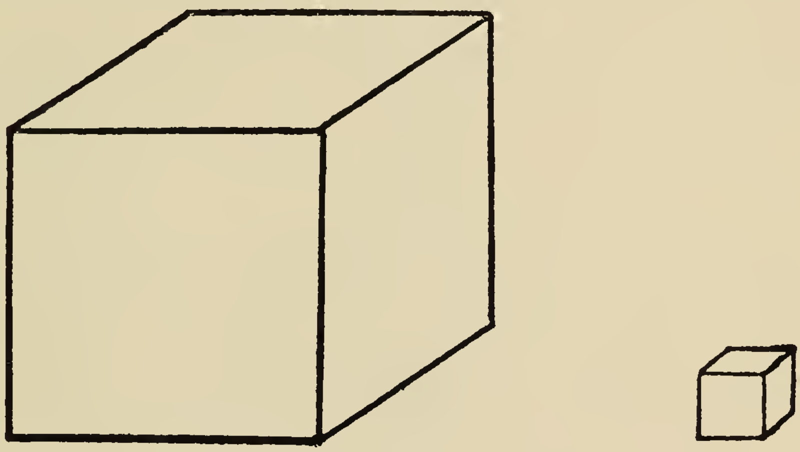


FIG. 4.

cubes here figured, which are of course many million times the natural size.

We must guard ourselves against the supposition that such changes are at all akin to mechanical comminution. No amount of grinding would achieve the result. In the laboratory it could only be effected (in the absence of animal extracts) by the employment of strong acids aided perhaps by high temperatures. In the body it is carried out in stages by a series of enzymes.

Osmosis.—Being resolved into simple diffusible substances, the next stage is assimilation or absorption. Here we are brought face to face with the problems of

osmosis, by which term is understood the passage of a dissolved substance through a membrane.

The cells of the body are both charged with fluid within as well as bathed with fluid without, and under these circumstances dissolved matters are continually flowing in and out through the semi-permeable membranous walls of the cells.

The three accompanying sketches represent in a crude way what might take place supposing a rectangular cell with its normal fluid contents were successively immersed

(1) (2) (3)

FIG. 5.

(1) in a fluid of molecular concentration equal to that within the cell. No change occurs in the dimensions of the cell;

(2) in a fluid of higher molecular concentration. The cell shrinks because fluid from within flows out faster than the outer fluid can enter;

(3) in a fluid of lower molecular concentration. The cell swells because the outer fluid gets in faster than the interior fluid escapes.

In the first case, the inward and outward flow being equal the two fluids are said to be *isotonic*. This means that the number of the dissolved molecules (or ions) in a given volume of either fluid is the same. For it is

not the percentage but the number of molecules or ions of dissolved diffusible matter that governs the rate of flow through membranes; they alone exert what is known as osmotic pressure. Neither undissolved nor colloidal (non-diffusible) substances influence the pressure.

Very important deductions can be drawn from a consideration of the above rules.

Firstly, nutrients must reach the villi in the shape of dilute solutions.

Secondly, having been taken up and distributed over the body, they must be promptly disposed of in some way, or the concentration of the cell fluids will be disturbed.

Adjustment of concentration.—The organism is in fact constantly engaged in adjusting this concentration of fluids in a most wonderful manner. Excess of water is carried off by the kidneys; dissolved nutrients may be dealt with in a variety of ways according to their character and the needs of the body. Sugar may be burned to carbonic acid and water, the former escaping with the breath; or sugar may possibly be stored to some extent after being converted into an indiffusible compound—glycogen, which can be rechanged to sugar when wanted. The protein fragments may either be rebuilt into protein—in that case body protein or flesh—or oxidised to carbonic acid, water and urea, the first removed by the lungs and the last two by the kidneys.

Not only does the organism regulate the concentration of the fluids—blood and cell contents—but it also has the power of controlling the escape of diffusible matters that may be required in metabolism. For example,

common salt is one of the most diffusible of substances, but if it be withheld from the diet, the body store of salt is to some extent eked out and does not diminish through losses via the kidneys at the rate it should do if simple osmosis were the only factor in its discharge.

Although the proportion of any one component of the body fluids is subject to variation, the concentration of all the diffusible matters taken together remains remarkably constant, not only in one person but in the whole race; and this notwithstanding the fact that every moment a readjustment must be made.

The intense suffering entailed by prolonged thirst is to be accounted for by the absolute necessity for preserving the normal aqueous dilution throughout the body.

Whether life began in the ocean or not, it is at least certain that even at the present day the protoplasm of every living thing, aquatic or terrestrial, carries on its vital processes in a very watery medium.

Fate of absorbed nutrients.—The nutrients having been absorbed by the villi, metabolism proper may be said to begin, for being carried by the blood stream to all parts of the body, they are quickly conveyed to the organs and tissues where the innumerable chemical metamorphoses comprised in the building up of living matter and its breaking down are proceeding.

We know but little of the actual chemical reactions occurring in the body-building processes, and it would not be within the scope of this work to discuss them if we did. We cannot always discriminate, moreover, between matters that are used wholly as building material and those which are merely utilised as fuel; but whether the food-stuffs have been through the entire cycle of changes between food, diffusible food-

educt, tissue, tissue waste, or have reached the final stage of waste product by a more direct route, the ultimate result will not be greatly different; it is the waste that food has to replace that chiefly concerns us.

What we do know is that the changes take place not in the blood and not in the lungs, but in the tissues generally. Blood aerated during its excursion through the lungs, where it has left the carbon dioxide picked up while on its journey through the body, brings to the tissues the oxygen which burns up both fuel and building material; but oxygen-charged blood (or the oxyhæmoglobin in it) cannot of itself effect this combustion in the tissues without the help of the chemical ferments or enzymes to which it has been so frequently necessary to allude.

Thus, glucose is not oxidised by oxyhæmoglobin alone, but in the tissues is broken up as follows:—

$$\begin{array}{ccccccc} C_6H_{12}O_6 & + & 6\,O_2 & = & 6\,CO_2 & + & 6\,H_2O \\ \text{glucose} & + & \text{oxygen} & = & \text{carbon dioxide} & + & \text{water} \\ \text{1 mol.} & & \text{6 mol.} & & \text{6 mol.} & & \text{6 mol.} \end{array}$$

The decomposition of fat is a little more complex, but the end products are the same:—

$$\begin{array}{ccccccc} 4\,C_3H_5(C_{18}H_{33}O_2)_3 & + & 320\,O_2 & = & 228\,CO_2 & + & 208\,H_2O \\ \text{olein} & & \text{oxygen} & & \text{carbon dioxide} & & \text{water} \\ \text{1 mol.} & & \text{323 mol.} & & \text{228 mol.} & & \text{214 mol.} \end{array}$$

Note the large quantity of oxygen needed to burn up fat.

In the case of a proteid, the combustion is still more complicated. We might represent a molecule of hæmoglobin as being burned in the following manner:—

$$\begin{array}{ccccc} 2\,C_{758}H_{1203}N_{195}O_{218}S_3Fe & + & 3235\,O & = & 195\,CO(NH_2)_2 \\ \text{hæmoglobin} & & \text{oxygen} & & \text{urea} \end{array}$$

$$\begin{array}{cccccccc} +\ 1321\,CO_2 & + & 813\,H_2O & + & 6\,SO_3 & + & Fe_2O_3 \\ \text{carbon dioxide} & & \text{water} & & \text{sulphur trioxide} & & \text{iron oxide.} \end{array}$$

This gives but a rough idea of the immense complexity of the changes that must occur, and it only attempts to enumerate the final products, supposing no others arise. In reality there would probably be a great number of intermediate substances formed.

Nitrogenous waste products.—The simplest and most natural terminal product to which the nitrogen of tissue or aliment might be brought by the crumbling down of the protein molecules would be ammonia, which, combining with carbonic acid and water simultaneously produced, would form ammonium carbonate; but that salt being strongly alkaline would upset the neutrality of the fluids and act destructively on the delicate living substance. Nature has solved this difficulty by selecting for the end product the harmless neutral body urea, which may be considered as ammonium carbonate minus the elements of water:—

$$\underset{\text{ammonium carbonate}}{(NH_4)_2CO_3} \quad - \quad \underset{\text{water}}{2\,H_2O} \quad = \quad \underset{\text{urea.}}{CO(NH_2)_2}$$

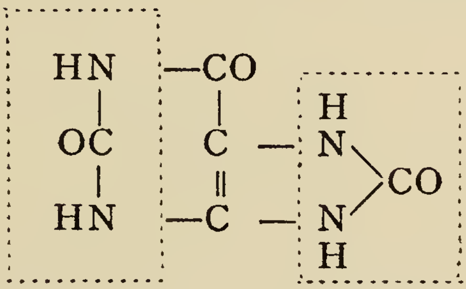
This substance is formed from protein decomposition products in relatively large amounts in the liver cells, and being readily soluble and diffusible is eliminated without trouble by the kidneys. Outside the organism it is liable to fermentation which changes it into the very salt—ammonium carbonate—which no doubt would have been the last stage in nitrogenous metabolism had not its alkalinity disqualified it.

Besides urea we find, in smaller quantities, other compounds of nitrogen among the waste matters, the most deserving of notice being creatine, creatinine and uric acid.

Upon the first two (which by the way are found in considerable proportion in meat extracts) we shall not

dwell longer than to say that creatine affords an example of a substance which although easily diffusible and found in all muscle does not pass out into the blood ; the creatinine found in the urine seems to be wholly derived from tissue waste and not from the food supply directly.

Uric acid.—Uric acid is of more general interest, and when present in the system in more than the normal amount (as in gouty persons) has a pathological significance. It is more complex in structure than urea, and what is of particular importance, it does not



easily dissolve ; it forms, too, very insoluble salts which have the unpleasant tendency to settle in the joints, causing great pain.

Its chemical composition shows that it should, if metabolism proceeded properly, be resolved into urea and carbon dioxide ; thus in the diagram each of the portions surrounded by a dotted line will yield a molecule of urea, while the central part will give three molecules of carbon dioxide if supplied with oxygen.

That quantity of uric acid which appears in the urine (and it is never entirely absent therefrom) is the residue which has escaped this oxidation ; for although the uric acid splitting enzyme found in animals has not yet been detected with certainty in the human body, there can be but little doubt that the greater

part of the uric acid produced in our bodies is destroyed there.

Origin of uric acid.—We see from the chemical constitution of uric acid represented above that it is built up from the configuration to which the name purine nucleus has been given ; only substances containing this grouping can be responsible for the formation of uric acid during metabolism. All who suffer occasionally from the consequences of deficient uric acid splitting power are naturally interested in these bodies and in knowing how to avoid them in their food.

The purine nucleus exists in all nucleo-proteids (see

```
N——C
C    C—N
        C
N——C—N
```

Purine nucleus.

Chap. III), and as these are widely distributed in our tissues we cannot avoid purine of ‘ endogenous ’ origin (that derived from breakdown of tissue), but we can of course reduce ‘ exogenous ’ purine (that derived from nutriment), and some authorities have gone to extremes in the advocacy of purine-free diet ; less biased physiologists (and we believe they are in the majority) doubt the wisdom of adopting such a diet ; others deny to it any therapeutic value whatever, reasoning that in withholding all purine we may possibly be depriving the organism of necessary building material. However this may be, it will probably be well for those afflicted by the gouty diathesis to abstain, at least when a gout attack threatens, from all aliment in which purine is at all abundant.

The relative purine richness of foods will be seen from the following tables :—

Purine Derivatives found in foods:

Hypoxanthine	$C_5H_4N_4O$	Abundant in meat extracts, sweetbread, liver, etc., present in small proportion in many other foods, or preparations used in foods.
Xanthine ..	$C_5H_4N_4O_2$	
Guanine ..	$C_5H_5N_5O$	
Adenine ..	C_5H_5N	
etc.		
Caffeine ..	$C_5H\ N_4O_2(CH_3)_3$	Chief sources, tea, coffee, cocoa.
Theobromine	$C_5H_2N_4O_2(CH_3)_2$	
Theophylline	$C_5H_3N_4O\ (CH_3)$	

Proportion of Purine Bodies in foods. [Compare Dr. Walker Hall 'On the Relation of Purin Bodies to certain Metabolic Disorders' (*Brit. Med. Jnl.*, June, 1902, 1462), also Dissertation, Owens College, Manchester.]

	Parts per 1000.	
Tea, coffee, cocoa	7 to 35	
Sweetbread	10	
Liver	$2\frac{3}{4}$	
Beef steak	2	
,, sirloin; Chicken	1·3	
Turkey	$1\frac{1}{4}$	
Pork, loin	0·5 to 1·2	
Beef, ribs; Ham (fat); Veal (loin); Salmon	$1\frac{1}{6}$	
Halibut	1	
Mutton, rabbit	1 nearly.	
Plaice	$\frac{3}{4}$	fractions of 1 part per 1000.
Cod, tripe, haricot beans	$\frac{6}{10}$	
Oatmeal	$\frac{1}{2}$	
Peameal	$\frac{4}{10}$	
Cabbage, lettuce, cauliflower; Asparagus	$\frac{2}{10}$	
Ale, porter	$\frac{1}{8}$ to $\frac{1}{6}$	
Onions	$\frac{1}{10}$	
Potatoes	$\frac{1}{25}$	
Milk, butter, cheese; Eggs (white), bread	traces.	
Claret, port, sherry	none.	

The most valuable of the purine-free foods are eggs and milk ; to them the uric acid sufferer has to turn in time of trouble.

In considering the other foods, or food adjuncts, other factors have to be taken into account. Tea, coffee and cocoa are in general not recommendable to the persons alluded to, but it must be remembered that although these materials figure at the top of the list, the actual quantity introduced by say a cup of coffee would be far less than that contained in a plate of beef. On the other hand, port or sherry might do more harm than a cup of cocoa, although the wine contained no purine at all.

Substances other than purine may be more incitive to uric acid secretion than purine derivatives themselves ; for instance, bread, which is almost innocent of purine, may lead to an excess of phosphoric acid formation and a deficiency of basic matter to neutralise it, whence a setting free of uric acid. [*Vide* Gautier, *Lancet*, 1907.] In an alcoholic beverage like beer the alcohol is less injurious than the other substances which accompany it, although not of a purine character.

Rules for the gouty.—The most rational means that suggest themselves for combating the uric acid diathesis are :

(1) Reasonable restriction of flesh food.

(2) Liberal consumption of water (to supply a sufficiency of solvent to carry away any uric acid unavoidably escaping destruction by oxidation).

(3) Adjustment of diet such that no undue acidity results from metabolic change. Beef, oatmeal, and wholemeal bread lead to excess of acid ;

peas, milk, prunes provide excess of base. [Sherman and Sinclair, *Jnl. Biol. Chem.*, 1907]. By combining foods of both these classes the desired neutrality may be arrived at.

(4) Avoidance of excessive fatigue. Moderate outdoor exercise is beneficial.

(5) Stimulation of oxidative and vital processes in general by living in as pure an atmosphere as possible.

Rôle of oxygen in metabolism.—Do we sufficiently realise how inseparably assimilation and metabolism are bound up with respiration ?

The main function of animal life is oxidation, and scarcely a step in the series of chemical changes proceeding within us is possible in the absence of an abundant supply of oxygen constantly renewed.

This element which, as we have seen (Chap. IV), we need in larger quantity than that of all the solid foods together, is provided for us in the form of a diluted gas from which only a small part is available, and in its hurried journey through the capillaries the tissues have but a second's time in which to abstract it.

It behoves us then to render this work as easy as possible by maintaining not merely an adequate supply but one of the maximum purity.

Living in close rooms lowers the vitality to an extent little dreamed of by many of us.

Endowed as the human organism undoubtedly is with wonderful powers of adaptation, it is at the same time extraordinarily sensitive ; its response to a dose of tuberculin weighing no more than a six-hundred-and-fifty-thousandth of a grain affords an example, and a further instance is provided by the fact brought

out by Wm. Thomson's experiments [Chem. Congress, 1909] that although the air in the open country may not differ so very greatly from that in a town, yet a person in the former atmosphere will expire 20 per cent. more carbonic acid than in town air in the same interval of time and under otherwise similar conditions. This means that he exhibits in the latter case only four-fifths of the vitality which he displays in purer air. (How devitalised must be those persons who habitually vegetate in close rooms !)

Persistent adverse conditions will eventually break down the resistance of the organism.

That deficient air and light are prominent factors in the spread of consumption is now thoroughly established; it is recognised too that the open air is the only healthy air, and it is pleasing to note that an ever-increasing number of individuals consistently endeavour to apply these truths to their own lives by maintaining their dwelling and sleeping rooms in a reasonable degree of purity; but there is still a large section of the community who fail to consider how great is the volume of air that each of us requires.

The following figures show what this volume is :—

Volume of air required.	Parts of carbonic acid in 10,000 parts.
Normal air contains of carbon dioxide . .	3 to 4
(That is the degree of purity we must aim at.)	
A healthy person will not tolerate air containing in the same volume more than . .	6 to 7
(Even the unwholesome persons who accustom themselves to a higher proportion of contamination cannot put up with much more.)	
Human breath contains on the average in the same volume (besides other substances less large in quantity but more toxic) . .	500

The average 11-stone man expires in 24 hours about 900 grammes of carbonic acid—say 2 lb.—containing 654 grammes of oxygen ($23\frac{1}{4}$ oz.). The atmosphere contains about one-fifth of that gas, but only one-twentieth is utilised in an inspiration.

Six hundred and fifty-four grm. of oxygen at 60° F. occupy 481·3 litres (17 cubic feet).

The volume of expired breath will therefore be 20 times this, or 9626 litres (340 cubic feet). Chittenden estimates it at 380 cubic feet.

But one measure of this expired air will vitiate, as the figures above indicate, 150 to 200 measures of the surrounding atmosphere to the extent of doubling its content of carbonic acid.

Consequently, the volume of air contaminated by one person to this degree in 24 hours is

50,000 to 67,000 cubic feet;
or say, 2000 to 3000 cubic feet per hour.

A bedroom 12 feet high would have to be 40 feet long by the same width to hold air sufficient for one man sleeping in it without ventilation for 10 hours.

For a person maintaining his weight the air needed is directly proportional to the food consumed.

Effects of impure air.—The immediate effects of breathing vitiated air are 'hyperpnœa, frontal headache, distress, flushing, cyanosis, and mental confusion.'

Vitiation of the atmosphere arising from respiratory products becomes most quickly apparent in warm weather, because in a lower temperature a larger proportion of objectionable components are condensed with the water vapour of the breath upon the walls and other cool objects in the room, the ambient air

being thus to some degree freed from them; the remaining impurities being less noticeable the need of ventilation is less appreciable and the occupants close the windows possibly. In warm weather, conversely, there being less of this condensation, the impurities are more readily detected.

Instead of reducing the air supply in cold weather (when we really require more rather than less air, since metabolism is in general more active) the proper course is to burn sufficient fuel in the grate to permit of maintaining in the apartment a comfortable temperature with the windows at least a little way open.

Contamination from coal gas.—Impurities other than those of respiratory origin occur in the air of rooms; gas-fittings are rarely gas-tight. In London there is a leakage of gas, partly within dwelling-houses and partly from the mains outside, of 1,700,000,000 cubic feet annually. Since the general adoption of incandescent gas mantles and the use of 'water-gas' in admixture with ordinary coal gas, the toxicity of our gas supply has been much increased. (Coal gas, even when largely diluted with air, produces headaches, languor, anæmia and other derangements.)

In London air, F. W. Andrews (*Trans. Pathol. Soc.*, 1903) found many bacteria, yeasts and moulds, but no disease organisms. (The smokiness of London's atmosphere seems to kill them.)

Other impurities.—We invariably find in the air of towns sulphurous, sulphuric and hydrochloric acids, and soot. The proportions of these impurities are small, but their aggregate quantity is immense.

The dust of a large town is complex and thickly populated with micro-organisms (the latter, fortunately,

mostly harmless); thus the Hon. Rollo Russell discovered in London air fragments of hay (the origin of this may be guessed), pinewood, linen and cotton fibres, feathers, skin, vegetable and mineral particles, besides micro-organisms so numerous that one man would inhale 37,000,000 of them in 10 hours. The dust particles, about 10,000,000 to the cubic inch, are 13,000 times as abundant as in the atmosphere over the ocean.

It should be added that London air has undergone a considerable improvement of late years.

Ventilation.—Whatever the outer air may be, and it is by no means always so dust-laden as the above description might lead us to infer—the constant rains prevent that—unchanged indoor air will be worse, so that we cannot afford to neglect ventilation at any time. In this connection it appears desirable to mention that 'ventilators' are often shams, or at best mere toys and wholly inadequate; the ancient theory that sufficient change of air is obtained by the current passing up the chimney is untrue, and the fear of 'night air' a superstition.

Ventilation of schoolrooms.—An excellent method, known as the 'blow-out' system, has been adopted in Cleveland, Ohio. At stated intervals, at the sound of a gong, the scholars leave the schoolroom either to play in the grounds or to go through physical exercises for a short time while the air of the classroom is thoroughly 'blown out.' Would that such a plan were universally enforced. The health of many children is seriously injured by the impure air of the classroom. *Thirty times* the normal amount of carbonic acid has been found in such rooms.

CHAPTER VI

THE BODY REQUIREMENTS. DIETARIES. THE FOOD RATIO, ETC.

What constitutes health?—Good health implies not merely an exact balance between physiological income and expenditure, but also that both shall be maintained at a high level; for like a motor which may be run at several speeds, the human machine may exhibit different degrees of vitality, the body cells displaying greater or less activity and the output in energy rising or falling in the same ratio.

Given adequate activity in repair, the vitality is the greater the greater the wear and tear.

The animal body an efficient machine.—In full health the animal body is more efficient as a machine for liberating energy from combustible material than is the best steam, oil or gas-engine in existence, and this fact permits us to calculate what are the bodily needs in food-stuffs, when the output in energy is known; for it has been proved again and again by placing a man in a chamber so constructed that all the heat emitted from his body and all the respiratory and metabolic products may be measured, that he yields the same amount of heat from a given amount of food-stuff completely consumed as would that food-stuff if burnt in a calorimeter. So that even without having recourse to such an elaborate research as an

experiment of that kind involves, we can calculate the heat or energy value of any food the composition of which has been previously ascertained.

Factors influencing bodily needs.—Many factors enter into the determination of the alimentary requirements of an individual, such as his height, weight, age and occupation, his tastes, fancies and idiosyncrasies, and the atmospheric and other conditions in which he lives. There is a considerable range too in the quantitative effects of these several influences; consequently it becomes manifestly impossible to provide data to fit every case, but there are certain general rules of wide applicability that will serve to indicate in which direction the dietaries given should be modified to suit particular circumstances.

The average man.—Taking an average man of 11 stone (154 lb. or 70 kilos.) it has been calculated that his chemical and physical losses are as under:—

Loss suffered by average man in 24 hours:—

By his breath, which measures about 350 cubic feet, he loses	
Carbon dioxide (CO_2) . . .	about 2 lb.
Water vapour	1 ,,
By his skin he exudes water vapour to the extent of	about 2 ,,
By his kidneys he excretes water .	say 3 to 5 ,,
,, ,, ,, urea . . .	1 oz.
In the excreta generally, nitrogenous matters other than urea	$\frac{1}{8}$,,
various solid substances . .	1 to 1$\frac{3}{4}$,,
salts	$\frac{3}{4}$ to 1 ,,

Traces of organic matter emitted by the breath and discharged through the pores of the skin are for the present not taken into account.

The total loss of energy expressed in heat units (1 calorie being the amount of heat required to raise 1 kilogramme of water 1° C., the so-called great calorie) will be—in round numbers—as follows :—

	Calories.
Heat required to warm the inhaled air . .	80
Heat lost in the water evaporated from the skin, say	400
,, ,, ,, ,, ,, lungs, say	200
,, ,, excreta	50
,, ,, from the surface of the body . .	1770
	2500

This would suffice to warm $2\frac{1}{2}$ tons of water 1° C. or $4\frac{1}{2}$ tons of water 1° F. ; in kinetic energy it is equivalent to lifting about 3000 tons one foot high.

Most of the lost energy is, as we see, due to the heat escaping from the surface of the body; but we must guard ourselves against the idea that this might be avoided to any large extent. Its suppression would mean arrest of vital change, for metabolic activity expends itself ultimately in the form of heat. Part, of course, may be preventible ; thus a man accustomed to dispense with an overcoat in winter might by wearing one preserve his body temperature with an ounce or so less starch than he had been in the habit of consuming in his daily food, but he is not necessarily the better for that physiologically. The truth of this is illustrated by the lassitude felt in warm climates and the extraordinary exhilaration produced in healthy individuals by great cold.

(This applies only to healthy persons ; to them cold weather may be really ' healthy,' but to the sick quite the reverse, the organism in their case being unable to rise to the occasion.)

The greater the muscular activity the greater the emission of heat.

Turning to the losses in weight we find the most serious to be due to the water eliminated by the breath, the skin and the kidneys; it is made good from the drink consumed, the moisture in the food and from the oxidation of hydrogen—an element common to all organic substances, as already explained.

The daily consumption of water in all forms is generally from 4 to 6 pints.

Carbon dioxide, the main product of combustion of all carbonaceous matters, whether burnt outside the body or oxidised within it, is an end product from every form of food, as well as from the breakdown of tissue, for they are all carbonaceous. Examples of the combustion of each type of food principle were given in the last chapter, where the origin of urea and uric acid was also discussed.

Energy value of foods.—We have now to consider to what extent each food principle is able to contribute towards the counterbalancing of our physiological expenditure.

Firstly, from the point of view of heat developed, we calculate the respective energy value of a food from the following data:—

1 gramme	of	protein yields on the average	4·1 calories
1 ,,	,,	carbohydrate (sugar or starch)	4·1 ,,
1 ,,	,,	fat	9·3 ,,

Judged by their energy values—apart from all other considerations—protein and carbohydrates are equal, while fats are $2\frac{1}{4}$ times as efficient.

Protein, however, having building properties not possessed by any other organic substances, cannot legitimately be replaced by any other food principles. Starch or sugar may to some extent act as substitutes

for fat, regard being had to the difference in calorific value stated above, but fat must not be eliminated altogether in this way; on the contrary it should form at least one-tenth to one-fifth the total dry solid matter of the diet. We may remember in this connection that fat is a very important component of the brain and nerves, while carbohydrates are not by any means abundant in any of our tissues.

Food ratio.—As to the proportion of protein that we should adopt in our diet, centuries of experience and the labours of the most illustrious of physiologists teach us that a proper ratio is ONE PART of PROTEIN to FIVE PARTS of NON-PROTEIN (fat and carbohydrate), and the proportion of fat being by the same experience fixed at about one-half the weight of the protein, we may decide upon the following as:—

The normal dietary:—

100	grammes	protein . . .	($3\frac{1}{2}$ oz.)
400	,,	starch and sugar .	($14\frac{1}{2}$ oz.)
50	,,	fat . . .	($1\frac{3}{4}$ oz.)

These are figures easily remembered; they are the averages based upon observations of the food consumed by persons in normal health doing moderate work. In the principal armies of Europe and in public institutions of various kinds they are followed more or less closely, and may be safely accepted as representing a normal dietary, generally recognised by physiologists as correctly supplying the needs of an average man of 11 stone normally active.

It is true that Professor Chittenden and his followers would have us reduce the protein supply very greatly, but excellent and painstaking as have been his researches it is questionable whether we should be acting wisely to depart radically from a system of dieting to

which our race has become accustomed by generations of usage; and if there be any doubt in this direction when considering the feeding of adults there can be but little when we come to that of children. In their case it would surely be highly injudicious to stint their tissue-building food.

We are told that very little of the 'flesh-forming' protein really forms flesh, a quite small proportion fulfilling that duty, the remainder being utilised directly for 'fuel.' That is no doubt the truth; but we have to remember that as the gold miner has to handle a large mass of auriferous quartz in order to extract a few grains of the precious metal, so may our system have to select from among a large assortment of nitrogenous molecules just a few atomic groupings with which to build up the tissues.

The quantities above named will be found to balance both the energy and the material losses, thus [*cf.* Koenig, 'Nahrung u. Genussmittel'].

Energy supplied by the normal diet:—

			Calories.
100 grm.	protein	at 4·1 cal. per grm. .	410
400 ,,	carbohydrate	,, 4·1 ,, ,, .	1640
50 ,,	fat	,, 9·3 ,, ,, .	465
			2515

Material yield from the normal diet and Main end-products of metabolism:—

Ingoings. Nutrients.		Oxygen from air.		Outgoings. Carbon dioxide.	Water.	Urea.
100 grm.	Protein with	152 grm.	yield	175 grm.	$43\frac{1}{2}$ grm.	$33\frac{1}{2}$ grm.
400 ,,	Starch or sugar ,,	474 ,,	,,	652 ,,	222 ,,	—
50 ,,	Fat ,,	$145\frac{2}{3}$,,	,,	$141\frac{1}{3}$,,	$54\frac{1}{3}$,,	—
550 ,,		$771\frac{2}{3}$,,		$968\frac{1}{3}$,,	$319\frac{5}{6}$,,	$33\frac{1}{2}$,,

Total $1321\frac{2}{3}$ grm. say $46\frac{3}{4}$ oz.

Total $1321\frac{2}{3}$ grm. $46\frac{3}{4}$ oz.

We are here dealing solely with the dry nutrients and the main waste products evolved from them; not with the water consumed or the salts. The 319 grm. of water mentioned is the quantity formed as a product of combustion.

Adjustment of food ratio.—To determine the proportion in which to combine two foods, the one rich in protein and the other poor in that constituent, so that in the two the normal ratio of protein to non-protein shall be contained, proceed as follows :—

Multiply the percentage of fat by $2\frac{1}{4}$ and add the product to any carbohydrate present, dealing with each food separately—this gives the carbohydrate equivalent; then

Per cent. carbohydrate equivalent less 5 times the per cent. protein in the food poor in protein (which we will call X) = 5 times the per cent. protein less per cent. carbohydrate equivalent in the food rich in protein (which we call Y). Thus: X = bread at say 56 per cent. carbohydrate and 7 per cent. protein.

Y = cheese at say 3 per cent. carbohydrate, 25 per cent. fat and 28 per cent. protein.

The carbohydrate equivalent in the case of the cheese is $(25 \times 2\frac{1}{4}) + 3 = 59\frac{1}{4}$: therefore we have

$$(56-35)\ X = (140-59\tfrac{1}{4})\ Y,$$

$$\text{or } 21\ X = 80\tfrac{3}{4}\ Y, \text{ whence } X = 3{\cdot}84.$$

That is to say, X, the weight of bread, should be nearly 4 times the weight of cheese.

For bread and milk the calculation would be :—

X = bread as above.

Y = milk: protein 3·5, fat 3·6, carbohydrate 4·8; 3·6 fat = 8·1 carbohydrate equivalent, with 4·8 = 12·9.

$(56-35)\ X=(17{\cdot}5-12{\cdot}9)\ Y$, or $21\ X=4{\cdot}6\ Y$.
Therefore $4{\cdot}5\ X=Y$.
i.e., to one part bread take at least $4\frac{1}{2}$ parts of milk.

Further examples have been worked out in the following table :—

Foods adjusted to normal ratio :—

Proportions.			Weights containing 100 grm. protein ($3\frac{1}{2}$ oz.).
1 part cheese	to 4	parts bread	$31\frac{1}{2}$ oz.
1 ,, flesh or fowl	$4\frac{2}{5}$	,, ,,	36 ,,
1 ,, beef steak	$4\frac{2}{5}$	,, ,,	38 ,,
1 ,, oatmeal	$2\frac{1}{3}$	,, milk	$55\frac{1}{2}$,,
1 ,, egg	$2\frac{4}{5}$	,, potatoes	$80\frac{1}{2}$,,
1 ,, bread	$4\frac{1}{2}$	,, milk	86 ,,
1 ,, rice	10	,, ,,	$93\frac{1}{2}$,,
1 ,, beef steak	7	,, potatoes	96 ,,
1 ,, green peas	1	,, ,,	$112\frac{1}{2}$,,
1 ,, potatoes	$2\frac{3}{4}$	,, milk	119 ,,

It is significant that some of the most commonly adopted pairs of foods fit in so well with the scientific ratio—such, for instance, as bread and cheese, which heads the list as the least bulky.

Distinction between ratio and quantity.—It must be understood that while the normal food ratio has a general application to all persons, excepting only the very young, the very old and sick persons, the actual quantities consumed (as distinguished from proportions) must be varied to suit the individual. We have to remember that the food required is proportional to the energy lost, this in turn being dependent upon the net quantity of active cell protoplasm (not simply the total weight of the body) and upon the relationship which the surface area of the body bears to the body weight.

These determining factors will be more easily comprehended from the following illustrations :—

Taking two persons of the same weight, the one thin and the other fat, the former will require more food than the latter because

(1) fat, being metabolically inactive, does no work (it is a fuel store for future use) ;—

(2) the thin person has more surface area (from which heat is continually radiating) than has the stouter person, for the surface area is greater the more an object deviates from the form of a sphere.

Rotundity has its advantage from one point of view —it is thermally economical.

The average human body has $2\frac{1}{2}$ times the surface area of a sphere of the same specific gravity and weight.

Comparing two persons of different weight—say 9 and 18 stone—but of a similar degree of fatness, the one of 18 stone will not need quite twice as much as the lighter individual, for although the surface of his body is greater it is not twice as great, the ratio of surface to weight being less than it is in the case of the smaller person.

The angularity of a man's body as compared with the more graceful contours of the feminine figure is accompanied in general by a smaller proportion of fat and a relatively greater surface area, both of which differences entail greater energy consumption.

From such causes as these a woman's needs are usually from four-fifths to nine-tenths of those of a man of the same weight.

In the first of the following diagrams the actual surface area (in square centimetres) is given for persons of different weights.

In the second a curve shows how the relative surface area falls as the body weight increases.

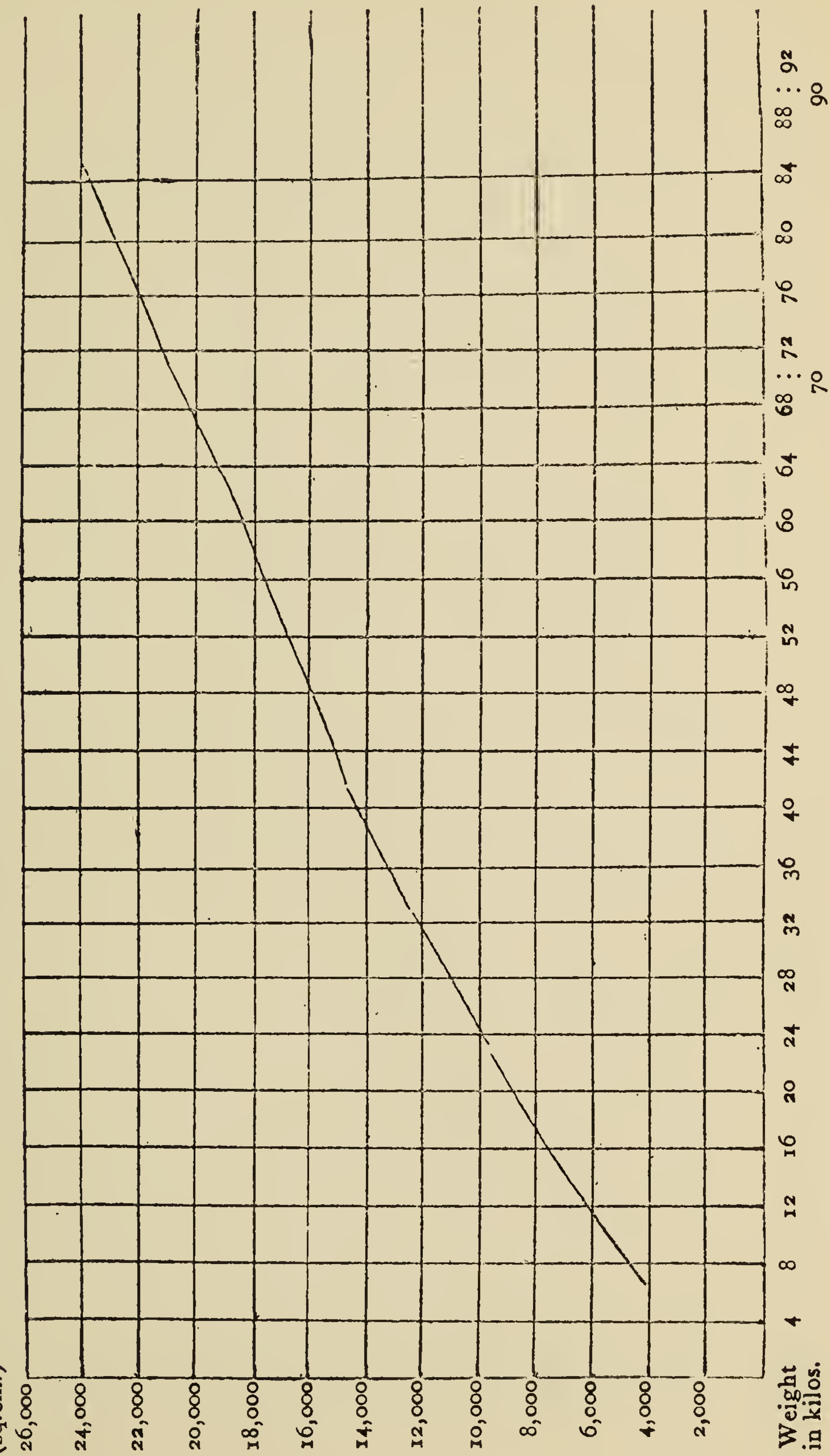


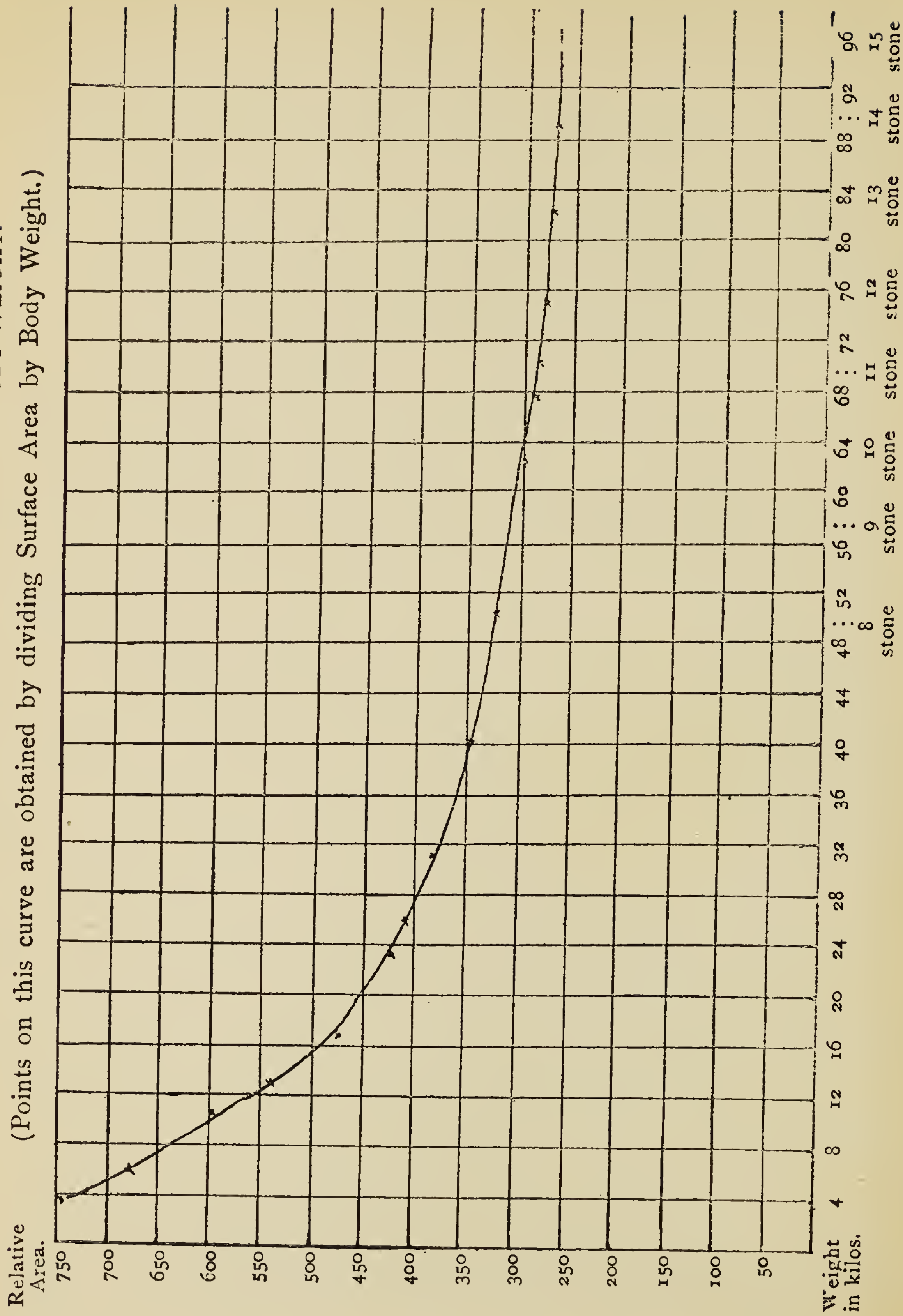
Fig. 6.

Surface Area and Body Weight.

Fig. 7.

Fall of Relative Surface Area with Increasing Body Weight.

(Points on this curve are obtained by dividing Surface Area by Body Weight.)



Normal Diet for Adults of Various Weights.—Keeping to the 100-gramme normal for an 11-stone man, we get the undermentioned quantities for persons of the weights specified, assuming a life of moderate activity and an age between 20 and 45. The young and those who have passed the more strenuous period of existence will be separately dealt with.

Weight.		Protein.		Carbohydrates.		Fat.	
stone	kilos.	grm.	oz.	grm.	oz.	grm.	oz.
8	50·8	81	$2\frac{7}{8}$	324	$11\frac{1}{2}$	40	$1\frac{1}{3}$
9	57·1	89	$3\frac{1}{8}$	356	$12\frac{1}{2}$	44	$1\frac{1}{2}$
10	63·5	94	$3\frac{1}{3}$	376	$13\frac{1}{2}$	47	$1\frac{5}{8}$
11	70	100	$3\frac{1}{2}$	400	14	50	$1\frac{3}{4}$
12	76·3	105	$3\frac{5}{8}$	420	$14\frac{5}{8}$	52	$1\frac{7}{8}$
13	83·7	112	$4\frac{1}{8}$	448	$15\frac{7}{8}$	56	2
14	90	118	4	472	$16\frac{2}{3}$	59	$2\frac{1}{8}$
15	96·4	127	$4\frac{1}{2}$	508	18	63	$2\frac{1}{4}$
16	101·6	133	$4\frac{3}{4}$	532	$18\frac{3}{4}$	66	$2\frac{1}{3}$

What these figures mean when translated into actual meals will be seen from the next table.

Example of a normal 24 hours' diet suitable for active but not hard work—say that of a City man of 11 stone :—

	Weight of foods taken.		Contents. Protein.	Fat.	Carbo-hydrates.
Breakfast—	oz.	grm.	grm.	grm.	grm.
Coffee					
Milk . . .	2	56·5	1·8	2·0	2·8
Sugar . . .	$\frac{1}{2}$	14	—	—	14
Bacon . . .	2	56·5	4·5	36·6	—
Egg, one . .	$1\frac{3}{4}$	50	6·2	6	—
Bread . . .	3	85	5·2	0·3	43·5
Lunch—					
Beef . . .	4	113	22·7	3·2	—
Potatoes . .	4	113	1·3	—	22
Bread . . .	4	113	7·4	1	58
Greens . . .					
Rice pudding .	4	113	4·5	5·2	38·3

	Weight of foods taken.		Contents. Protein.	Fat.	Carbo-hydrates.
	oz.	grm.	grm.	grm.	grm.
Tea—					
Tea . . .					
Milk . . .	2	56·5	1·8	2	2·8
Sugar . . .	½	14	—	—	14
Bread . . .	3	85	5·2	0·3	43·5
Butter . . .	½	14	—	12·9	—
Dinner—					
Fish (whiting) .	2	56·5	12·1	—	—
Fowl . . .	4	113	26·0	4	—
Potatoes . .	3	85	1	—	16·5
Cauliflower . .					
Bread . .	6	170	10·4	0·6	88·4
Custard and fruit .	3	85	3	4	24·5
Cheese . . .	½	14	4·2	4	—
	49¾	1407	117·3	82·1	368·3

In these meals the fat is above and the starch below the respective normals, 50 and 400, but converting the excess fat=32·1 into its equivalent of starch=72·2, the carbohydrate total becomes 440·5, which is near enough for all practical purposes; it allows a margin for indigestible matters. No count is taken here of small traces of nutritive substances; thus green vegetables and fruits, although very desirable components of a menu, mainly on account of the natural food salts which they supply, add scarcely anything to the totals of protein and fat, and but little to that of the carbohydrate (unless eaten in large quantities), so their food value has been ignored. This would be unjustifiable if we were dealing with the richer fruits, and still more so in the case of dried ones such as raisins and currants; but even these contain but little protein and are nearly free from fat.

By the help of the tables in which the composition

and yield of nutrients are given any number of normal menus may be constructed without difficulty.

Effect of occupation upon energy expended and food needed.

Our normal diet of 100 protein, 50 fat and 400 carbohydrate (reckoned in grammes) is capable of yielding energy equivalent to 2500 calories.

The amounts of energy expended by men in various pursuits were found by Rubner to be :—

Monk in retirement	2000
Office work	2500
Professional work (doctors)	2631
Moderate muscular work (house painter)	3121
Hard muscular work (shoemaker)	3659
Severe ,, ,, (navvy)	5213
Exceptionally heavy work (brick-making)	8000

The consumption of nutrients by men doing work of various degrees of severity, and the calorific equivalent to the energy involved, as determined by other authorities are :—

	Calories.	Protein.	Fat.	Carbohydrates.	Food ratio.
Moderate muscular work—					
Voit	3055	118	56	500	1 to 5·2
Playfair	3140	119	51	531	1 ,, 5·4
Atwater	3500	125	—	—	—
Hard muscular work—					
Voit	3370	145	100	450	1 ,, 4·6
Playfair	3630	156	71	568	1 ,, 4·7
Severe muscular work—					
Playfair	5750	185	71	568	1 ,, 3·9
Atwater	5700	175	—	—	—

Dietary studies made in the United States (U.S.

Bulletins Nos. 75 and 98, 1901) indicate the following as averages for the classes named :—

	Calories.	Protein.	Fat.	Carbo-hydrates.	Food ratio.
College clubs . .	3690	107	148	459	1 to 7·4
Mechanics' families .	3465	103	150	402	1 „ 7·1
Farmers' „ .	3515	97	130	467	1 „ 7·8
Professional men .	3325	104	125	423	1 „ 6·7

The small ratio of protein in the American dietaries is accounted for by the large quantity of fat consumed in proportion to other food; the weight of protein, however, is remarkably close to the normal.

Diet of Athletes (*loc. cit.*) :—

	Calories.	Protein.	Fat.	Carbo-hydrates.	Food ratio.
Weston, average of last 5 days of 5000 mile walk (50 miles per day)	4850	235·8	64·6	800	1 to 4·1
Miller, 6 days' bicycle race, 2007 miles (1898)	4770	169	181	585	1 „ 5·9
Pilkington, 3 days of same race . .	4610	211	178	509	1 „ 4·3
Football team, college students, Connecticut	5740	181	292	557	1 „ 6·8
Football team, college students, California .	7885	270	416	710	1 „ 6·1
Harvard University crew at Cambridge . .	4130	162	175	449	1 „ 5·2
Yale University crew at Newhaven . .	3705	145	170	370	1 „ 5·1
Prize fighter, English, while at Washington, D.C. (his food was nearly wholly meat) .	2205	278	78	83	—

An inspection of this table brings out one fact very strikingly, and one in direct contradiction with the doctrine that laborious work necessitates no greater consumption of protein than ordinary work.

Theoretically this may be true; that is to say that

extra work may be performed for a time without extra protein, but practically we find that whenever men have to endure severe muscular labour they not only demand more 'fuel,' i.e., carbohydrate and fat, but also enormously increase their 'building material,' i.e., protein.

The diet for training, as judged by the food consumed by a large number of athletes in various parts of the world, is one in which :

Firstly, and this is the most important, all indigestible combinations like pastry must be excluded ; in other respects restrictions are few.

Secondly, it must be very liberal, so as to supply an adequate amount of energy-yielding material.

Thirdly, it should contain a larger ratio of protein than ordinarily required.

Exercise must be commensurate, in order that the extra food is really used up; the tissue cells are thus brought to the highest attainable degree of activity and all surplus water and fat eliminated from the system.

Here are the items composing the menus of the Harvard crews above referred to :—

Beef : Roast loin, fillet and rib.
,, Broiled loin, steak.
,, Baked.
Lamb : Broiled chops, roast leg.
Poultry : Roast turkey, chicken fricassé, capon.
Fish : Broiled mackerel, bluefish.
Soups : Chicken, chicken and tomato, etc.
Milk ; cream.
Oatmeal boiled (rolled oats) ; rice boiled with sugar and cream.

Rice custard.
Bread toasted.
Potatoes creamed, mashed and seasoned.
Pudding: Apples and tapioca, Indian corn, etc.
Macaroni, egg omelettes.
Vegetables: Green peas boiled, asparagus, cabbage, onions, spinach.
Fruits, etc.: Prunes, orange marmalade, strawberry jelly.

A good example of a substantial, varied and nutritious diet for an active life is afforded by the following typical menus provided for men of the United States Navy (*Daily Mail*, March, 1912):—

Monday.—Breakfast: Scrambled eggs, fried potatoes, bread, butter, coffee.
Dinner: Hot roast beef, gravy, stewed tomatoes, potatoes, bread, butter and coffee.
Supper: Fried liver, onion gravy, boiled potatoes, bread, butter and tea.

Tuesday.—Breakfast: Fried pork sausage, hot cakes with syrup, bread, butter and coffee.
Dinner: Fricassé of veal, green peas, mashed potatoes, bread, butter and coffee.
Supper: Railroad hash, hot biscuits, jam, bread, butter and tea.

Friday.—Breakfast: Fried eggs, oatmeal with milk and sugar, bread, butter and coffee.
Dinner: Roast veal, gravy, Lima beans, potatoes, bread, butter and coffee.
Supper: Cold corned beef, macaroni

and cheese, rice pudding, bread, butter and tea.

Saturday.—Breakfast: Beef stew with dumplings, bread, butter and coffee.

Dinner: Hamburger loaf, gravy, string beans, baked potatoes, bread, butter and coffee.

Supper: Fried pork chops, gravy, potatoes, fruit turnovers, bread, butter and tea.

Sunday.—Breakfast: Baked pork and beans, ketchup, rolls, bread, butter and coffee.

Dinner: Chicken fricassé, green peas, hot biscuits, mashed potatoes, bread, butter and coffee.

Supper: Steamed 'franks,' fried potatoes, tinned fruit, bread, butter and cocoa.

For a dweller on land it would be advisable to introduce a little more fruit. Tea and coffee at every meal, too, is not altogether recommendable.

Effect of age upon metabolism.—The food required runs parallel with the bodily activities, rising steadily from birth to the age of 20 to 24, at which period it is at a maximum; assimilation then slows down very gently, scarcely perceptibly in the majority of cases, until about 45, rather more appreciably from 45 to 65 or 70, and then comparatively rapidly, so that at 80 the protein and fat consumption have sunk to a fifth or sixth, and that of the starch to perhaps half the original level.

Of course this is but a general rule subject to exceptions; many a man preserves his vitality considerably beyond the 'allotted span.'

Height, Weight and Rate of Growth

Dr. C. Duke examined 7709 men and boys of the most favoured classes—public school boys, naval and military cadets, and medical and university students—with the following results :—

Age last birthday.	Height without shoes. inches (average).	Growth. inches.	Mean inches.	Mean growth.	Weight (including 9 lb. clothes). Average lb.	Growth. lb.	Mean Weight. lb.	Mean Growth. lb.
10	53·4	—	53	—	67·4	—	67	—
11	54·91	1·51	54·5	1·5	72·9	5·5	73	6
12	56·97	2·06	56·5	2·0	80·3	7·39	80	7
13	58·79	1·82	58·5	2·0	88·6	8·27	88	8
14	61·11	2·32	61	2·5	99·2	10·61	98	10
15	63·47	2·36	63·5	2·5	110·4	11·21	110	12
16	66·4	2·93	66·5	3	128·3	17·92	126	16
17	67·8	1·46	68	1·5	141	12·69	140	14
18	68·29	0·43	68·5	0·5	146	4·97	146	6
19	68·72	0·43	68·75	0·25	148·3	2·20	148	2
20	69·13	0·41	69	0·25	152	3·87	150	2
21	69·16	0·03	—	—	152·3	0·27	152	2
22	68·93	—	—	—	154·7	2·44	—	—
23	68·53	—	—	—	151·7	—	—	—
24	68·93	—	—	—	149·2	—	—	—
25–50	69·06	—	69	—	155·2	0·42	154	2

What should be the body weight for a particular height ?

Dr. John Hutchinson weighed and measured some 5000 persons of all classes, and selecting from these 2650 healthy and vigorous men, obtained the following average results for each inch in stature :—

Averages for healthy men :—

Height.				Weight.		
ft.	in.	in.		st.	lb.	lb.
5	1	61	..	8	8	120
5	2	62	..	9	0	126
5	3	63	..	9	7	133
5	4	64	..	9	13	139
5	5	65	..	10	2	142
5	6	66	..	10	5	145
5	7	67	..	10	8	148
5	8	68	..	11	1	155
5	9	69	..	11	8	162
5	10	70	..	12	1	169
5	11	71	..	12	6	174
6	0	72	..	12	10	178

The relationships between the weights of a man and a woman of the same height are rather curious, thus :—

Between the heights of 5 ft. 1 in. and 5 ft. 4 in. the woman is from 10 to 12 lb. lighter than the man ; at the heights 5 ft. 5 in. and 5 ft. 6 in. the woman is from 6 to 7 lb. lighter ; at the height of 5 ft. 7 in. and 5 ft. 8 in. she has the same weight. Above that height she gets gradually heavier than the man, her weight at 6 ft. being, on the average, 13 stone 5 lb., or 9 lb. more than the man of that height.

Of course these are only average figures ; a person of either sex may deviate considerably from the above normals and yet be perfectly healthy.

What are the foods actually consumed in an average

English family?—The average family will be found not among the income-tax payers (of whom there are rather over a million in the United Kingdom), but among the far more numerous class whose incomes fall below £160 per annum; of these there are nearly 8 million families, representing nearly 40 million persons; and as the working classes constitute the great majority of them, we give below from the Board of Trade Report

The Average Urban Working-man's Weekly Budget:—

			s.	d.
32 lb.	Bread and flour	costing	3	7
6½ ,,	Meat bought by weight		4	5½
	Other meat, including fish			11¾
1⅓ ,,	Bacon			11½
	Eggs		1	0
	Nearly 10 pints fresh Milk		1	3¼
13¼ oz.	Cheese			6½
2 lb.	(nearly) Butter		2	1½
17 ,,	Potatoes			11
	Vegetables and fruit			11
11¼ oz.	Dried Currants and raisins			2¾
3 lb.	(nearly) Rice, tapioca and oatmeal			6
10 oz.	Tea		1	1½
3½ ,,	Coffee and cocoa			3¾
5⅓ lb.	Sugar			11¾
	Jams, marmalade, treacle, syrup			6½
	Pickles, condiments			3¼
	Other items		1	9¼

Out of an average income of 37 shillings per week the food bill takes 22 shillings.

A calculation of the contents of these foods shows the food ratio to be 1 to 7 (one of flesh-formers to 7 of non-protein principles reduced to their starch equivalent), instead of 1 to 5, the normal ratio; this is accounted for by the rather too large proportion of

bread, flour and potatoes. One notes, too, that the expenditure upon fruit and vegetables is relatively small.

Living at minimum cost.—With the object of providing the maximum nourishment at the minimum expense a number of dietaries have been compiled of which one or two noteworthy examples will be given.

Professor W. H. Thompson's weekly dietary for a family of five costing 8s. 6*d. in Dublin*[1] *:—*

		s.	d.
15½ lb.	'Standard' flour	2	0¼
7 ,,	Oatmeal		11
7 pints	Milk		8¾
5 ,,	,, skimmed		2½
21 lb.	Potatoes		8¾
3 ,,	Barley, hominy, peas or lentils		5
2 ,,	Dripping		10
1 ,,	scrap Beef, 1½ lb. breast mutton		11¼
	5 Herrings		3¼
	Vegetables		3
1½ ,,	Sugar		3
5 oz.	Tea		5
1 lb.	Syrup		1¼
	Sundries		4½

The food ratio is about 1 to 6, the diet therefore is better balanced than that of the average working-man's family, but it is far less liberal, and would doubtless soon prove unendurably monotonous.

Economical rations were also made the subject of careful study by Dr. Delepine (Archives of the Public Health Laboratory, Manchester, 1906). In the following figures the 7 daily rations (which were varied for each day in the week) are added together for better

[1] Cost in London, at the time the dietary was calculated, would be 9s. 6d. to 10s.

comparison with the dietaries just given, but it will be observed that the food is not for a whole family.

Dr. Delepine's Economical ration, one week's food for an adult man, 'together with a share for the children,' and calculated to supply daily 125 grammes protein, 125 grammes fat and 450 grammes carbohydrate.

7	lb.	Bread (1 lb. each day).			
$4\frac{1}{2}$	,,	Potatoes (used on 5 days).			
7	quarts	Milk (1 quart each day).			
3	oz.	Rice (used on two occasions).			
18	,,	Flour ,, ,, ,, ,,			
2	,,	Oatmeal (used once).			
1	,,	Macaroni ,, ,,			
$14\frac{1}{4}$	,,	Mutton	(used at	3	meals).
8	,,	Beef	,, ,,	1	meal
4	,,	Pork	,, ,,	1	,,
4	,,	Liver	,, ,,	1	,,
$4\frac{2}{3}$	,,	Bacon	,, ,,	2	meals
3		Herrings	,, ,,	2	,,
1		Egg			
9	,,	Margarine	,, ,,	5	,,
2	,,	Suet	,, ,,	1	meal
1	,,	Dripping	,, ,,	1	,,
$8\frac{1}{2}$	,,	Cheese	,, ,,	5	meals
1	lb.	Sugar	,, ,,	7	,,
$1\frac{3}{4}$	oz.	Tea	,, ,,	7	,,
5	,,	Peas, 2 oz. beans (used at 2 meals).			

DIFFICULTIES OF VEGETARIANISM

The meat eater has this advantage over the vegetarian that he can procure his nutriment in a less bulky and generally more digestible form.

The vegetarian is apt to point to the pulse foods as being equal to, if not more nutritious than meat. It is a fallacy based upon a comparison between peas and beans in a desiccated, uneatable state and meat

in the natural undried form. Compared under like conditions we find great differences :—

	Percentage of Protein.
Dry peas and beans	20 to 24
Dried lean meat	85 ,, 90
Green peas and beans . . .	3 to 6
Raw lean meat	18 ,, 21

Peas, beans and lentils are among the most nutritious of vegetable foods, but there is a defect common to them all which it has not yet been found possible to wholly remove, namely their imperfect digestibility. The tissue of flesh breaks down under the solvent action of the digestive secretions, and both the contents of the cells as well as their linings are rendered available for nutrition ; but the nutrients of the leguminous seeds—as of vegetables generally—are ‘ walled up ’ in cellulose which the human digestive fluids are powerless to dissolve. Some of the vegetable tissue bursts in cooking, other portions give up their contents in part through the cell walls ; on the average, however, some 20 per cent. of the protein from one cause or another traverses the system without being absorbed, so that a diet already much more voluminous than that of the meat eater must be made still more so to make up for this waste.

A vegetarian will point also to nuts as containing much nutriment in a compact form. The difficulty is that it is too compact, and the form such that the masticatory and digestive resources of the modern town dweller are unfitted to cope with the aliment except in very limited quantities.

These are the chief vegetable foods rich in protein (milk, eggs and cheese, so generally consumed by

pseudo-vegetarians, belong of course to the animal kingdom); practically all other vegetable foods are either like green vegetables—very poor in protein, or like potatoes—surcharged with starch.

If we could find a vegetable food that in percentage of proteid nutrients, in stimulating properties and in digestibility rivalled roast beef, the most serious drawbacks of vegetarianism would be removed.

CONCENTRATION

There is a widespread notion (fostered by fanciful writers) that the compression of a meal into a nutshell or of a lunch into a lozenge is quite within the realm of possibilities, in fact merely one of those achievements that will inevitably follow future advances of science.

Attractive though such a vision may be, it is nothing better than an idle fancy, and must for ever remain one.

A food-stuff like bread might be considerably reduced in bulk by expulsion of water—usually nearly 40 per cent.—and elimination, by compression, of the air spaces with which it is permeated. We should then have transposed a light, easily assimilated food into a hard, compact mass difficult to masticate. But having removed water, air and the little carbonic acid gas associated with it, we should have reached the absolute limit; reduction of volume can be carried no further.

Our normal dietary treated in the same way would occupy the following space:—

100 grm.	dry protein about	82	cubic cm.	or say 5	cubic in.
400 ,,	starch or other carbohydrate .	250	,,	,, 15¼	,,
50 ,,	fat . . .	54	,,	,, 3¼	,,
	Total	386	,,	or about 23½	,,

Liquids and solids, even under tremendous pressure and great cold, are compressible to quite a trivial extent. A pound of sugar will always fill at least the space of half a pint of water, no matter what we do; nothing can be taken from its bulk without removing or destroying some sugar, and unless in the future we learn how to feed on uncombined carbon or how to upset Nature's laws by putting two portions of matter into the same space—say two pints of water into a one-pint measure—we cannot hope to squeeze the solids of our normal ration (550 grm. = 29 oz.) into a smaller compass than about 386 cubic centimetres, roughly $\frac{3}{4}$ of a pint.

It is the irreducible minimum, and in tablet form would be represented by 424 twenty-grain lozenges or 1700 five-grain pellets.

Some six pints of water would have to be drunk before this absolutely dry food could be digested.

By desiccation the liability of foods to decomposition is much reduced or even entirely prevented, and transport greatly facilitated, but—advantageous as that undoubtedly is—we have to remember that digestibility is by no means enhanced.

A number of dried foods are now manufactured, such as evaporated milk, desiccated potatoes, green vegetables, etc., also casein and other dried protein food-stuffs; these are referred to under their appropriate headings.

CHILDREN'S DIET

Upon those who have the care of children rests a weighty responsibility. The future welfare as well as the present happiness of their protégés; whether their life shall be a long fight with a weakly constitution—

perhaps diseased—or a happy career pursued in full health and mental vigour.

To their food, the air they breathe, and the hygienic condition of their surroundings we must look for the answer. Mental training, of vast importance in itself, must be subordinated to the physical needs of the body; only when these are adequately and, in fact, liberally met can we hope for any satisfactory development of the brain.

The alimentary requirements of the adult are more sharply defined than those of the child; the former has but to balance a relatively moderate degree of wear and tear; during the growing period, however, we have to compensate for an expenditure of energy that is far more intense than in those of maturer years. Let there be no lack of material!

How shall we gauge a child's needs?—While the extent of surface of the body by affecting the escape of warmth must necessarily in corresponding measure influence the amount of 'fuel' needed—as already explained—a more convenient guide to the alimentary requirements is afforded by the body weight considered in conjunction with the age of the child.

From the fact that a child at the breast consumes only about 1 gramme of protein per kilo of its weight (6·35 grm. or hardly $\frac{1}{4}$ oz. to the stone of 14 lb.), certain physiologists[1] have contended that older children and adults too should be satisfied with a like proportion. If we are to accept such a contention as this, might we not with equal reason argue that since a new-born infant cannot walk we should refrain from that exercise?

[1] e.g. Siegert, Meeting of Scientists, Munich, 1906. Chittenden reasons somewhat similarly.

As far as can be ascertained, no child has ever been reared or has ever subsisted without injury for any lengthy period upon so low a proportion of protein. On the contrary, innumerable investigations carefully conducted in various parts of Europe by eminent scientists indicate convincingly that a child requires far more than the infant ratio.

The lengthiest and most painstaking research upon the nutrition of children was that of Camerer, which was carried on uninterruptedly for twenty years, his own offspring being the subjects. His records, which were most carefully compiled throughout that period, are infinitely more instructive and valuable than the multitudinous experiments of short duration that we are so frequently entertained with.

A short test upon feeding has but little or no value, and when performed with, let us say, rats, instead of human beings—as is so often done—may be ludicrously misleading.

Camerer's figures emphasise what we have already pointed out, namely, the large demand which Nature makes upon the child. Here are some results contrasted with those for the average man of 11 stone :—

				Protein required per diem.
Child of 15,	Weight	5 st. 8½ lb.	(35·7 kilos) ..	50·8 grm.
,, ,, 12½,	,,	5 st. 1¾ lb.	(32·6 ,,) ..	50·8 ,,
,, ,, 9,	,,	3 st. 13¼ lb.	(25·1 ,,) ..	49 ,,
,, ,, 7,	,,	3 st.	(18·8 ,,) ..	40 ,,
,, ,, 5,	,,	2 st. 7½ lb.	(16·2 ,,) ..	35·3 ,,
,, ,, 3,	,,	2 st. 1¼ lb.	(13·3 ,,) ..	31·7 ,,
,, ,, 1,	,,	1 st. 9¾ lb.	(10·8 ,,) ..	34·5 ,,
Man	,,	11 st.	(70 ,,) ..	100 ,,

The values observed by Camerer, Uffelmann, Herbst, Baginsky, Erich Mueller and many others, range, for

children of from 2 to 6 years, from 3 to 4½ grm. protein per kilo (*Biochemische Zeitschrift*) or ¾ oz. per stone as a general average.

As the child grows older the total consumption increases, but the relative amount—the amount per kilo body weight—falls nearly to the adult level, i.e., about 1½ grm. per kilo, or ⅜ oz. per stone.

A child of	2 years	requires	⅓	as much as a	man's diet.
,,	5	,,	⅖	,,	,,
,,	6–9	,,	½	,,	,,
,,	10–15	,,	½–¾	,,	,,

Until the fourth year, milk should constitute half the diet, and from the fourth to the eleventh year one-third; this means from a pint to a pint and three-quarters daily.

In the following dietaries by Koenig the proportion of milk should be increased for children of 6 to 10, and the whole diet reduced by about ¼ to ⅓ for those ages.

General diets for children of 6 *to* 17 :—

(1)

170 grm.	=	6	oz.	meat (raw weight).
300 ,,	=	10½	,,	bread.
180 ,,	=	6½	,,	potatoes.
15 ,,	=	½	,,	fat (butter, lard or other fat).
250 ,,	=	8½	,,	milk.
100 ,,	=	3½	,,	meal (for supper).
180 ,,	=	6½	,,	vegetables.

(2)

100 grm.	=	3½	oz.	meat (raw weight).
25 ,,	=	1	,,	cheese.
300 ,,	=	10½	,,	bread.
180 ,,	=	6½	,,	potatoes.
20 ,,	=	¾	,,	butter or other fat.
250 ,,	=	8½	,,	milk.
100 ,,	=	3½	,,	meal.
180 ,,	=	6½	,,	vegetables.

(3)

100 grm.	=	3½ oz.	eggs (2 eggs).
100 ,,	=	3½ ,,	peas or beans.
250 ,,	=	8½ ,,	bread.
180 ,,	=	6½ ,,	potatoes.
25 ,,	=	1 ,,	butter or other fat.
100 ,,	=	3½ ,,	meal.
180 ,,	=	6½ ,,	vegetables.
150 ,,	=	5¼ ,,	milk.
150 ,,	=	5¼ ,,	beer (?).

Tea, coffee, etc., extra.

During youth an excess of nutrients above the calculated normal appears to do but little or no harm; safeguards being found in the natural limitations of appetite. Dr. A. T. Schofield went so far as to say (Gresham Lecture, Oct., 1906): 'Until 21 eat as much as you like,' to which might be added, 'due regard being given to the proper balance of food principles.'

Of course the infant in arms cannot be given *carte blanche* in this fashion.

[Infant feeding is separately considered in a succeeding chapter.]

Variety in a child's food is all-important.

CHAPTER VII

INFANT FEEDING

Whenever Nature's provision for the infant's nutrition is available infant feeding becomes a very simple matter. But in an ever-increasing number of cases this is not so; the mother has to seek for a substitute.

Cows' milk in some shape or form must be had recourse to, and our first duty then is to ascertain in what way human milk differs from cows' milk and how the latter may be modified in order to reduce these differences to a minimum.

The following table gives a bird's-eye view of the principal divergencies of composition and character of the two secretions:—

	Human Milk (Fluctuations).	Cows' Milk (Fluctuations).
Fat	1·3 to 7·6	1¾ to 5¾
Proteids: Casein	0·2 ,, 1·9	2½ ,, 3⅔
Albumin	0·3 ,, 2·5	0·3 ,, 0·7
Milk sugar (lactose)	1¾ ,, 8⅔	3⅔ ,, 5¾
Ash	0·13 ,, 1·9	0·5 ,, 0·8
Specific gravity	1·020 ,, 1·036	1·027 ,, 1·035

The general averages may be taken to be:—

	Human Milk.		Cows' Milk.	
Fat	3¾		3½	
Casein	0·8	2% protein	3	3⅓% protein
Albumin	1·2		0·33	
Milk sugar	6⅓		5	
Ash	0·3		0·7	

	Human Milk.	Cows' Milk.
Specific gravity .	1·030	1·031
Reaction . .	faintly alkaline	slightly acid
Remarks—		
Fat . . .	Generally rather more than in cows' milk.	Rather too little fat.
Casein . . .	Always much lower than in cows' milk (usually only one-fourth.)	Too much casein.
Albumin . .	Generally 3 times as much as in cows' milk.	Too little albumin.
Sugar (lactose) .	Generally $\frac{1}{5}$ more than in cows' milk.	Rather too little sugar.
Mineral matter .	Generally half as much as in cows' milk ($\frac{1}{3}$ to $\frac{1}{2}$ as much iron).	Twice as much mineral matter as in human milk.
Action of gastric fluid . . .	Forms small, quickly-digested clots.	Forms large coarse clots that disturb the infant stomach.
Fat globules . .	Smaller and more easily digested.	—
Microbes and other contaminations . .	None if healthy mother.	Dirt of various kinds not uncommon. Innumerable micro-organisms.

If we except the last-named contaminations, which are adventitious, these divergencies correspond to the differences in the requirements of the young infant and the young ox respectively. The one a small, fragile creature which in proportion to its light body weight has a large surface area, necessitating a higher ratio of warmth-producing food to tissue-building

elements; the other a large, rapidly growing animal with a much smaller relative surface area,[1] requiring much bone and other tissue-forming material and a lower ratio of heating food (being, in addition to the difference in proportional surface area, provided with a natural heat-retaining coat).

Cows' milk then is never the best food for an infant and only a second best when suitably modified.

Humanised milk.—A variety of processes have been devised for converting cows' milk into 'humanised' milk, i.e., a fluid resembling human milk. The principles involved are: firstly, dilution with water—or better, sweet whey—to reduce the proportion of casein; secondly, addition of cream and milk sugar to restore the proportions of those ingredients.

Adopting as our standard for human milk 2 per cent. protein, 6 per cent. lactose and 3¾ per cent. fat, and having at hand milk sugar (dry), cows' milk of average composition, and cream containing 40 per cent. of fat (we will deal with poorer cream later), the quantities to be mixed when water and not whey is the diluent will be :—

Formula (1)—
56 parts cows' milk.
35¾ „ water (boiled and cooled).
3 „ milk sugar. (Commercial milk sugar occasionally contains moulds. To destroy them, boil it with the water used for dilution).
5¼ „ cream (40 per cent.).

If, as is done for the first week or so, we require to bring down the proportion of protein to 1 per cent., the quantities will be :—

[1] The larger the body, the smaller the proportional surface area, and *vice versâ*.

Formula (2)—

25	parts	cows' milk.
63¼	,,	water (boiled and cooled).
7¼	,,	cream of 40 per cent.
4½	,,	milk sugar.

Instead of trusting to a bought cream prepared by a cream separator which yields a product containing a high percentage of fat but one which is usually borated before delivery to the public, we may allow fresh milk to stand 12 hours in a tall narrow vessel *placed in a cool spot protected from flies and dust,* collecting after that time the cream which has risen, and mixing a suitable quantity with milk of the latest delivery (not with milk of the same delivery as that from which the cream has been taken).

In such cream we should find a much lower percentage of fat than that upon which formulas (1) and (2) have been based; it would probably contain about 16 per cent. of fat, in which case formulas (3) and (4) would give the proper ratios for admixture.

Formula (3) for use when a 16 per cent. cream is available and the mixture is to contain 2 per cent. of protein :—

46	parts of	milk.
14	,,	cream.
3	,,	milk sugar.
37	,,	water.

Formula (4) for use with a 16 per cent. cream and when 1 per cent. of protein is required in the mixture :—

8½	parts of	milk.
21½	,,	cream.
4½	,,	milk sugar.
65½	,,	water.

N.B.—Unless the milk when standing is kept cool, we run risks from :—

(1) Contamination from the surrounding air.
(2) The rapid multiplication of the organisms already present in the milk.

Both are sources of serious danger, and in the warm weather the method may become impossible in the absence of a refrigerator.

A small cream separator would remove the greater part, if not all the risk, because by its means separation of cream can be carried out in a few moments.

In all the above formulæ the ratio of casein to albumin remains the same as in cows' milk ; that is to say the possibility of the mixture forming larger clots in the stomach than is desirable has not been removed.

Should this give trouble, the introduction of a small quantity of boiled barley water is generally sufficient to provide a medium such that the particles of curd formed in the stomach are hindered from cohering.

Barley water may appear to be an undesirable ingredient in the food of a very young infant, since starch should not be given until the child is from 4 to 6 months old, but when used in very moderate proportions the amount of starch introduced is so small that it does not apparently do any harm, or but rarely. In some cases it must be very sparingly used, or digestive disturbances may ensue, possibly even skin eruptions. Chavasse recommends as an alternative in such cases a very little thin jelly made from pure gelatine.

Correction of the acidity of cows' milk.—To remove the slight acidity normal to cows' milk, lime water to the extent of *one-twentieth* of the volume of the food

may be incorporated (replacing water or whey if the latter is an ingredient—see below). No larger proportion of lime water than the one indicated must be used, for excessive alkalinity is injurious.

Whey mixtures.—Should it be desired to lower the ratio of casein to albumin in order to approach to the composition of human milk still further than has been done in the preceding formulas—a step that seems to be necessary only in a minority of instances—the procedure becomes far more complex, so much so in fact that outside help from a laboratory or firm specially qualified to undertake the blending of ingredients may have to be requisitioned. Where the parents or nurses feel competent to carry out the several manipulations it will be necessary to bear in view the following facts, upon which the success of the series of processes depends :—

(1) Rennet when mixed with milk (skimmed milk is best for this purpose) throws down the casein, after a few minutes, leaving albumin (lactalbumin) in solution.

(2) The further action of the rennet must be stopped, otherwise casein present in that portion of milk which is not to be treated with rennet would be also precipitated when making up the mixture.

(3) Blood heat is the best temperature for rennet action.

(4) The rennet enzyme is 'killed' at about 60° C. (140° F.).

(5) Lactalbumin (whey proteid) is thrown out of solution (coagulated) between 74° and 84° C. (165° and 183° F.).

(6) If after rennet action we heat the whey to 65° C. (140° F.) we shall 'kill' the rennet enzyme without coagulating the lactalbumin.

Preparation of whey.—For infant feeding it is most convenient to prepare the whey from separated milk, otherwise the proportion of fat in the finished product is more uncertain. To the fresh skimmed milk add a small piece of rennet or a few drops of rennet extract; let stand at blood heat for half an hour or until curd has formed; strain through fine muslin. Collect the fluid which runs through, i.e., the sweet whey. Raise this to 65° C. before mixing with the other ingredients.

Inaccuracies of whey formulas.—It may be remarked here that many published formulas for whey mixtures assume the whey to be free from casein, or in other words, that the 'whey proteids' contain no casein, but where prepared as above described, a by no means negligible proportion of the substance in question passes through the sieve. This casein being in a finely divided state is not likely to be harmful, but we ought not to ignore its presence. Many examples of infant food prescriptions, too, are worked out into quantities which are curiously inaccurate even in works otherwise excellent.

Instance of miscalculation :—

Prescription.		Calculated mixture.	
Fat . .	3 per cent.	Cream of 16 per cent.	$3\frac{3}{4}$ oz.
Milk sugar .	6 ,, ,,	Fat-free milk .	$\frac{1}{2}$,,
Whey proteid	0·75 ,, ,,	Lime water .	1 ,,
Caseinogen .	0·25 ,, ,,	Whey . .	$14\frac{3}{4}$,,

The caseinogen in this combination really contains three and one-half times the proportion prescribed. In

reality it is quite impossible to follow the prescription with a 16 per cent. cream.

The assumption made by the same authorities that mixtures containing $1\frac{1}{2}$ per cent. of lactalbumin and 0·5 per cent. caseinogen can be made in the manner outlined is also incorrect. The author who cites the above prescription and the mixture designed to accord with it gives the ratio of caseinogen to albumin in cows' milk as 3 to 1, but it is really 6 or 7 to 1; consequently the calculated compositions of the mixtures deviate very markedly from the truth.

It is manifestly impossible to prepare a mixture containing a higher proportion of lactalbumin than is present in any one of the ingredients, and none contains as much as 1 per cent. The only way to reach $1\frac{1}{2}$ per cent. would be to concentrate the whey at a temperature below 65° C. in a vacuum—a procedure quite outside the scope of the ordinary householder's resources.

A good whey mixture for the first few weeks.—We give one example of a whey mixture—the most favourable possible with ordinary facilities :—

Formula (5)—

9	parts	cream of 40 per cent.
$89\frac{1}{2}$	,,	whey.
$1\frac{1}{2}$	,,	milk sugar.

This food would, generally speaking, be serviceable only for the first few weeks, except in cases of great gastric sensitiveness. Later a mixture such as those of formulas (1) and (3)—if well borne—should be substituted, but with the proportion of water gradually reduced.

Advantages and disadvantages of whey mixtures :—

Advantages.	Disadvantages.
Excessive casein eliminated.	Very troublesome to prepare.
Large clots in the stomach avoided.	Costly if purchased ready made.
	Composition difficult to check.
Digestion said to proceed more smoothly.	Not invariably successful.

Opinions upon whey mixtures are very contradictory, thus :—

'Laboratory milk unsatisfactory. Has never seen an infant below the age of 10 months who could tolerate a laboratory mixture containing over $1\frac{1}{2}$ per cent. of proteids.'—[Dr. Louis Starr.]

'The objection entirely fallacious. Has never had the slightest difficulty in providing a healthy infant with the full amount of proteids required.'—[Dr. Ralph Vincent, the great champion of the system of 'divided proteids,' i.e., whey mixtures.]

In most cases it would seem that whey mixtures may be dispensed with.

Average quantities of food required by infants in 24 hours.—It will be understood that no hard and fast rule can be drawn as to an infant's requirements, but the following may be taken as a rough guide :—

	grm.			grm.	oz.	
First week . .	300	in 10	feeds	of 30	say 1	each time
2nd to 6th week .	350 to 450	,, 8	,,	of 40 to 60	,, $1\frac{1}{2}$ to 2	,, ,,
6th to 12th week .	500 to 700	,, 6	,,	of 80 to 120	,, 3 to 4	,, ,,
4th to 5th month	700 to 900	,, 6	,,	of 120 to 150	,, 4 to 5	,, ,,
At 6 months .	1000	,, 6	,,	of 166	,, 6	,, ,,
At 10 ,, . .	1150	,, 5	,,	of 250	,, 8	,, ,,

Condensed milk as an infant food. (For composition of condensed milks see ' Dairy Produce.')

After appropriate dilution condensed milk prepared from *unsweetened* full cream milk offers certain advantages over uncondensed milk, more especially in large towns during the summer months, when the freshness of the milk supply leaves much to be desired. For with condensed milk we avoid risk of disease germs, and although it may not be quite free from non-pathogenic organisms, the numbers present are quite insignificant compared with the microbial population of a similar quantity of London's ' fresh ' milk supply.

Condensed *sweetened* whole milk is much less suitable —one might say unsuitable—notwithstanding the regrettable fact that thousands of infants are brought up upon it and thrive in spite of it. How many die from it is less easy to ascertain.

Condensed sweetened whole milk if used at all should be regarded as a temporary expedient only, not to be continued for any lengthy period.

Dr. Louis Starr, quoted in Dr. Coutts' Report (see below), says : ' Infants fed upon condensed milk (meaning the sweetened variety), though fat, are pale, lethargic and flabby, and though large are far from strong ; have little power to resist disease ; cut their teeth late, and are very liable to drift into rickets before the end of the first year.'

Dr. Eric Pritchard, *loc. cit.*, is even more emphatic : ' I have never yet seen an infant fed for 6 months uninterruptedly on condensed milk who did not present unmistakable symptoms of rickets.'

Use of orange juice.—The danger of scurvy from too

long use of condensed milk may be avoided by occasionally giving the child a little orange juice.

Condensed sweetened skimmed or separated milk.—Whatever may be said for condensed whole milk, nothing but condemnation of the most emphatic kind can be applied to the use, for infant feeding, of skimmed milk in any shape or form. Here are some of the consequences arising from the attempt to rear infants upon skimmed milk :—

> "Malnutrition—emaciation and atrophy—rickets, scurvy, lowered vitality with consequent lessened resistance to all diseases, and with increased liability to certain diseases, such as diarrhœa. A considerable proportion of the infants die during the first year of life . . . and those that survive are apt to be stunted, ill-developed, of poor physique, and physically and mentally of a less efficient type. . . . Even when malnutrition is less pronounced a diet showing a marked excess of carbohydrates in relation to other food elements appears to result in perverted metabolism, leading to the overgrowth of mucoid forms of connective tissue as compared with more highly organised tissues, and the infant is in consequence more liable to bronchitis, pneumonia, tonsillitis, adenoids and diarrhœa."—[Dr. F. H. Coutts. Report to the Local Government Board on condensed milk.]

The only form of condensed milk for infants.—Of the several forms of condensed milk, we see that only that prepared from *unsweetened unskimmed* milk can be recommended. A well-reputed brand should be selected.

Adjustment of condensed milk to infant feeding.—For dilution, which should be done with weighed quantities and only such quantities as are immediately required, it may be assumed (provided one of the best brands be used) that 1 part *by weight* of unsweetened condensed whole milk needs 2 parts *by weight* of boiled water in order to reduce it to the concentration of ordinary cows' milk. (A sweetened condensed milk would require more water.)

The fluid so obtained can then be dealt with just as if it were actually fresh cows' milk, being treated further according to one or other of the formulas (1) to (4)—whichever appears best adapted to the age or health of the child.

N.B.—Unsweetened condensed milk does not keep so well as the sweetened variety after the lid has been raised; therefore only small-sized tins should be bought, and, after opening, should be kept covered in a cool place away from dust. Examine it for soundness before use.

Recapitulation of warning.—To feed an infant upon skimmed milk, condensed or otherwise, is to court disaster.

To feed it upon sweetened condensed milk is to handicap it in its struggle for life.

To feed it upon suitably modified fresh, clean cows' milk is to give it a fair but a long way from the best chance of life.

To feed it as Nature designed is to provide it not only with the right food, but all the comfort and happiness which it so sorely lacks in all other methods.

These axioms receive awful confirmation in the following figures cited by Dr. Coutts in the report to

which reference has already been made. For instance, in Derby during 1900-3 Dr. Howarth found the

Death rate among breast-fed babies was .	69·8 per 1000
,, ,, ,, hand-fed ,, ,, .	197·5 ,, ,,

Among the latter the

Death rate of those fed on cows' milk was	177 per 1000
,, ,, ,, ,, condensed milk was	255 ,, ,,

(Possibly skimmed milk was partly responsible for this frightful rate of mortality.)

The deaths from diarrhœa among breast-fed babies was	8·6 per 1000
The deaths from diarrhœa among hand-fed babies was	51·7 ,, ,,

In Brighton, 1903-5, Dr. Newsholme found that of 121 infants who died from epidemic diarrhœa

The breast-fed amounted to . .	6·5 per cent.
Those fed on cows' milk . . .	36 ,, ,,
,, ,, condensed milk . .	30 ,, ,,

On sterilisation and pasteurisation.—To the methods of, and security conferred by, pasteurisation and sterilisation some space has been devoted in the Chapter on 'Dairy Produce'; it remains for us here to consider the suitability to infant feeding of milk so treated.

It must be said at the outset that, as in many other problems of dietetics, there are two opposed schools of thought in regard to the effects of heated milk upon children. While a large number of doctors are strongly against the use of sterilised milk for infants, others speak of it in the highest terms. With respect to pasteurisation, which implies a less severe heating of the milk and therefore less change in it, the divergence

of opinion is not so marked, and we find opponents of sterilisation advocating pasteurisation.

Opposed to sterilisation.—Look-Meinert despondingly declares that Soxhlet's process has produced a 'sick generation.'

Dr. Ralph Vincent, who has done good work upon the subject of 'divided proteids' (see whey mixtures), speaks of the fatal effects of boiled milk, and says: 'When you boil milk you kill the organisms that the child requires' (meaning the lactic bacteria) 'and leave those that kill it, as the putrefactive organisms cannot be killed by boiling.' (This latter assertion is not quite true. It would be more correct to say that these organisms are not so easily killed by boiling.) He proceeds: 'The Infants' Hospital, started in 1903, had from the first used raw milk, and no case of zymotic enteritis had ever occurred within its walls.'

Drs. Doane and Price, in answer to a circular inquiry, received replies from a number of doctors, all of whom objected to sterilisation. Most recommended raw milk *if pure*; otherwise it was to be pasteurised.

For sterilisation.—The favourite contention of those who declaim against pasteurisation or sterilisation is that perfectly pure cows' milk is far better; but where can we be sure of obtaining that 'perfectly pure' milk? Dr. Collingridge, when Medical Officer of the City of London, had a number of London milk samples examined in 1904-5, with the following results:—

	1904	1905
Clean and pure . . .	49 per cent.	68 per cent.
Unclean . . .	45 ,, ,,	23 ,, ,,
Tubercular . . .	8 ,, ,,	9 ,, ,,

Of course the purity and cleanliness of the milk

supply might, and can, be greatly improved. In the Frankfurt '*Milchküche*' (milk kitchen or depot) the milk on arrival must contain not more than 1000 organisms per cubic centimetre—London milk generally contains more than 2 millions in the same volume —the milk has to be kept cold until sterilised (it is heated for 5 minutes to 100° C., then rapidly cooled), and only 6 hours elapse between milking and delivery to the consumer.

Drs. Walter Cronheim and Erich Mueller (*Biochemische Zeitschrift*, 1908) state that sterilised milk is not inferior to raw milk so far as metabolism of nitrogenous, fatty and lime compounds are concerned. Any unfavourable effect (i.e. if any) must be due to causes at present unknown.

Nathan Strauss, who has carried out a wonderful infant life-saving crusade in New York, reduced the infant mortality among the city's waifs on Randall's Island from 440 per 1000 to 198 per 1000 by feeding them on pasteurised milk.

> Speaking of those who opposed pasteurisation [International Chemical Congress, London, 1909], he alluded to the 'noisy clamour of those who did not know and who would not believe. . . . One New York physician went so far as to declare that his clinic was thronged daily with babies who had contracted scurvy or rickets by being fed upon pasteurised milk. . . . Dr. Green, who went to his clinic to see the anomaly, found that the "belligerent doctor *failed to show a single such case*."'

> Hygienic Laboratory, Bulletin No. 41 (U.S.): 'Milk and its relation to the public health.'—'A com-

plete and thorough vindication of pasteurisation . . . showing its necessity, and proving scientifically that the heat necessary to kill the germs of disease does not impair the ferments that assist digestion, does not lessen its food value, does not alter its chemical or physical qualities, but does prevent sickness and save many lives.'—[Strauss, *loc. cit.*]

Dr. Variot, after several years' experience with sterilised milk in France, concludes: (1) Milk heated to 105° C. (221° F.) has lost nothing of its nutritive value. (2) The destruction of enzymes, alteration of milk sugar, of lecithin or the precipitation of lime salt that may occur have no notable effect. (3) No case of rickets or scurvy was observed among infants fed upon sterilised milk, but occasionally constipation and pallor. (4) Only 4 per cent. of the infants did not support sterilised milk.

Of 20,000 infants fed on sterilised milk, Grasset found only four with Barlow's disease (infantile scurvy).—[Dr. Percy Waentig, Arb. Kais., *Gesundheitsamt*, 1907.]

PROPRIETARY FOODS FOR INFANTS

Were it not for one or two exceptions one might until recently have defined proprietary foods for infants as 'foods which infants ought not to have.' Manufacturers persistently supplied, at prices far above the intrinsic values, a variety of farinaceous preparations wholly unsuitable for the feeding of infants. Usually these 'patent' foods (not patented at all) were charged with starch—which, as we all know, young infants are incapable of assimilating—and devoid of fat, which,

as we are equally well aware, is so vitally important to them.

Need we wonder at the fearful infant mortality?

Nowadays one is able to point to very substantial improvement in both directions; the mortality, still unfortunately much too high, is steadily falling, while infants' foods of quite scientific excellence are to be had at any chemist's.

The purchaser still needs to exercise caution, however, the safest course being to select a food the composition of which is declared on the package—that composition being such as to be adapted to the age of the child—and to reject everything of which the ingredients are unknown. Particular attention must be given to the proportion of fat, a deficiency in which may often have the most disastrous consequences.

CHAPTER VIII

MEATS, FISH, GAME, ETC.

THE similarity in structure and composition of the flesh of animals to that of our own bodies, the power which our digestive and assimilative mechanism possesses of breaking down animal protein and reconstructing from the fragments human flesh, and the lack of anything in the vegetable kingdom so well adapted to the repair of our unceasing waste of tissue, combine in giving to meats an exceptional rôle in our nutrition.

By their richness in protein and generally low or moderate proportion of non-protein, they permit of the utilisation of other foods which are poor in the former and overcharged with the latter, thus enabling us to adjust the balance between the two classes of nutrients.

Composition of lean meats.—Whether from bird, beast or fish, the lean part of meat is remarkably uniform in composition so far as the main principles are concerned; broadly speaking it consists of:—

Water . . . . (80 or more in fresh fish)	usually	74	to	77	per cent.
Muscular fibre, etc. (mostly protein)	,,	13	to	18	,, ,,
Connective tissue (also protein)	,,	2	,,	5	,, ,,
Fat (distributed through the lean)	,,	0·5	,,	4	,, ,,
Albumin (protein) . .	,,	0·5	,,	4	,, ,,
Salts	,,	about		1	,, ,,
Meat bases (digestive stimulants)	,,	0·08	to	0·4	,, ,,

In addition to these there exist in meat small quantities of many other compounds which need not however concern us here (*cf.* Chap. III).

Protein forms one-fifth.—The muscular fibre, connective tissue and albumin constitute the protein which, as a rough general rule, forms one-fifth of the weight of the lean flesh.

Composition of lean meats exclusive of bone:—

		Water.	Protein.	Fat.
Quadrupeds—				
Beef		73 to 77	19½ to 21	1 to 4
Mutton		75 ,, 76	17 ,, 20	5 ,, 7
Veal		72 ,, 79	18 ,, 20	5 ,, 7
Pork		72 ,, 75	18 ,, 20	5 ,, 7
Venison		71 ,, 78	19 ,, 22	2 ,, 4
Rabbit		72 ,, 77	20 ,, 23½	1 ,, 6
Hare		65 ,, 75	22 ,, 30	1 ,, 4
Birds—				
Fowl		73 ,, 76	18 ,, 23	1 ,, 3
Duck, wild		70 ,, 73	20 ,, 22	2 ,, 5
Goose, wild		73 ,, 75	19 ,, 21	2 ,, 4
Pigeon		72 ,, 76	20 ,, 22	1 ,, 3
Partridge		72 ,, 75	21 ,, 25	1 ,, 3
Fish—				
Salmon		74 ,, 77	15 ,, 16½	4 ,, 7
Perch	average	78	18½	1
Whiting	,,	76	21½	0·3
Sole	,,	77	19	1·5
Plaice	,,	80	17	1·5
Cod	,,	81	16	1
Trout	,,	74	23	1
Haddock, fresh	,,	72	23	1

When we consider meats with adhering fat, the percentages necessarily vary much more widely; in general, however, it is the water that is most reduced as the fat accumulates, so that, so far as the total nutritive matter goes, fat meat is more advantageous

than that which is lean, although the proportion of tissue-building protein is lower.

General Table of Flesh Foods

(The lean and fat together, but bone excluded.)

	Water.	Protein.	Fat.
Beef, lean	73 to 77	19½ to 21	1½ to 4
,, moderately fat	63 ,, 75	16 ,, 19	9 ,, 17
,, very fat	33 ,, 63	11 ,, 18	18 ,, 55
Veal, lean	72 ,, 79	18 ,, 20	2 ,, 8
,, moderately fat	64 ,, 72	15 ,, 18	9 ,, 17
Mutton, lean	75 ,, 76	17 ,, 20	5 ,, 7
,, moderately fat	65 ,, 74	14 ,, 17	9 ,, 20
,, very fat	40 ,, 63	12 ,, 16	25 ,, 50
Pork, lean	72 ,, 75	18 ,, 20	5 ,, 8
,, moderately fat	49 ,, 72	16 ,, 18	9 ,, 30
,, very fat (bacon)	23 ,, 48	9 ,, 16	35 ,, 65
Rabbit, lean	72 ,, 77	20 ,, 23½	1 ,, 6
,, fat	65 ,, 68	19½ ,, 21½	6 ,, 12
Hare	61 ,, 75	22 ,, 30	1 ,, 6
Venison	71 ,, 78	19 ,, 22	2 ,, 4
Bear (analysis by Strohmer)	65	26	5
Birds—			
Fowl, lean	73 to 76	18 to 23	1 to 3
,, fat	68 ,, 72	20 ,, 22	3 ,, 8
Duck	60 ,, 72	19½ ,, 24	3 ,, 12
Goose	40 ,, 74	10 ,, 21	5 ,, 45
Pigeon	65 ,, 75	20 ,, 22	1 ,, 10
Fish—			
Herring family :			
Herring	66 ,, 76	15 ,, 21	3 ,, 11
Shad	65 ,, 75	18 ,, 20	6 ,, 12
Sardine (see prepared fish).			
Salmon family :			
Salmon	61 ,, 71	15 ,, 24	3 ,, 15
River trout	74 ,, 80	18 ,, 23	1 ,, 6
Sturgeon	72 ,, 80	16 ,, 19	1 ,, 2
Perch family :			
Perch	75 ,, 80	17 ,, 20	0·5 ,, 1
Pike	75 ,, 80	15 ,, 20	0·2 ,, 1

	Water.	Protein.	Fat.
Mackerel family :			
Mackerel . .	64 to 78	17 to 20	3 to 15
Tunny . . .			
Mullet . . .	70 ,, 76	17 ,, 20	3 ,, 8
Eel . . .	70 ,, 75	17 ,, 19	7 ,, 10
Cod . . .	80 ,, 83	15 ,, 18	0·3 ,, 0·6
Plaice family :			
Plaice . . .	75 ,, 80	17 ,, 19	1 ,, 3
Flounder . .	80 ,, 84	13 ,, 15	0·5 ,, 1
Halibut . .	70 ,, 80	17 ,, 20	3 ,, 10
Skate . . .	75 ,, 83	15 ,, 19	1 ,, 3
Molluscs, Crustacea, etc. :			
Oyster . . .	84 ,, 90	4 ,, 9	1 ,, 3
Lobster . .	75 ,, 85	12 ,, 18	$1\frac{1}{2}$,, 3
Crab . . .	75 ,, 82	14 ,, 17	1 ,, 2

Prepared fish—

	Water.	Protein.	
Dried cod . .	14 to 18	77 to 80	—
Smoked and salted cod	45 ,, 55	22 ,, 30	salts 15 to 25
Smoked and salted mackerel . .	40 ,, 60	15 ,, 25	salts 10 ,, 20 fat 15 ,, 25
Salted herring . .	40 ,, 52	18 ,, 20	salts 14 ,, 18 fat 15 ,, 20
Salted and smoked salmon . .	45 ,, 55	22 ,, 27	salts 10 ,, 15 fat 10 ,, 12
Sardines in oil . .	50 ,, 55	20 ,, 24	salts 2 ,, 5 fat 25 ,, 35

General properties of the constituents of meats.—By far the major part of the nutritive constituents of meat exists therein in the form of muscular fibre *insoluble in water* (cold or hot), but soluble after having been acted upon by the gastric and pancreatic fluids. It represents four-fifths of the nitrogenous nutrients of flesh.

Next in importance is the connective tissue which surrounds the muscle fibres ; on long boiling with

water it dissolves gradually, being converted into gelatin. The latter is not a true tissue-former, but is utilised in the system as fuel and is also credited with tissue-sparing properties.

Then we have a small quantity of albumin, a substance soluble in cold water but coagulated when the temperature is raised; in the coagulated state albumin is insoluble in either hot or cold water, although, like muscular fibre, it yields to the solvent action of the digestive secretions.

Apart from fat, which we need not describe here (see Chap. III), there remain to be mentioned only the meat bases and mineral salts.

By meat bases we understand the alkaloid substances: creatinine, xanthine, etc., which resemble caffeine, the active principle of tea and coffee; they are nerve stimulants.

The meat bases and about half the mineral salts are dissolved out by water.

Attempts to dissolve the nutrients of flesh.—From time immemorial efforts have been made to extract from meat its nutrient principles by boiling with water; in our own times, while the older and simpler methods have not been discarded, more elaborate processes, based upon deeper knowledge of the digestive functions, have been introduced; but both the old and the new attempts have met with failure or at least with but indifferent success. The explanation is simple.

Extraction with water alone was predestined to fail for the reason given above—the insolubility of the principal components. The more scientific attempts at solution, involving the use of Nature's own ferments

(generally obtained from the stomachs of pigs or oxen), were successful only in a physical or physico-chemical sense; peptonisation and solution were really accomplished, but, strange to say, the result was a physiological failure, for solutions so prepared can only be employed medicinally and not as foods at all. If consumed in more than medicinal doses they disturb the system, acting in fact as purgatives.

The conversion of insoluble proteids into soluble albumose and peptone represents, it is true, the early stage of normal digestion, but it is evident that these substances when formed within the human body are very quickly changed into other compounds before they can do any harm, but if presented to the stomach in quantity these further changes do not take place with sufficient rapidity.

The contents of the preceding paragraphs may be tabulated thus:—

Action on Flesh Foods of

Natural Digestion.	Artificial Peptonisation.	Boiling Water.
Practically the whole of the nutrients dissolved and assimilated.	Solution effected but resulting product a medicine rather than a food. Cannot be consumed in quantities.	Nutrients left insoluble: 13 to 20 per cent. of the original meat. Gelatin, 2 to 5 per cent., meat bases, fraction of 1 per cent., and a little mineral salt taken up.

How small in amount and relatively unimportant are the water-soluble matters!

Column 3 shows why beef-tea, bouillon, soups and the like are stimulants rather than foods; they have,

in fact, very little nutritive value, although of course not devoid of utility.

From columns 2 and 3, considered together, we draw this very significant deduction: THERE IS NO TRUE MEAT EXTRACT; that is to say there is none which contains all the nutrients of the meat in a form such that by taking at one meal a quantity of the preparation sufficient to supply the whole of the protein of an ordinary dinner no disturbance of the stomach would result.

We shall revert to this subject under the heading 'Meat Extracts.'

Nerve stimulants in meat and in tea.—As meat contains in general only a few parts per 1000 of these substances, it might be thought that their quantity is not worth considering, but it is not so. In half a pound of meat there is at least one and a half times as much of these nerve-stimulating principles as would be found in half an ounce of dry tea, which we may regard as an ordinary daily dose.

How to judge meat.—The lean of beef or mutton freshly cut should have a bright red colour, uniform throughout, i.e., free from patches of a darker or lighter hue than the surrounding flesh. It should have a certain firmness combined with sufficient elasticity to recover its shape quickly after pressure with the finger.

There must be no signs of wounds or evidence of disease such as fatty degeneration of the muscular fibres, crystalline deposits, or infiltration of blood into the fat.

An excessive leanness is undesirable, for it often indicates that the animal from which the meat was taken was in inferior health. Such meat, on touching

with the finger, is easily compressed, but only slowly regains its form after pressure has been withdrawn. On exposure to the air it dries abnormally fast and acquires a brown colour; lastly, the proportion of water is above the average and the nutritive value consequently lower than it should be.

The flesh of too young an animal is very gelatinous, less nutritious than that of a better developed member of the same species, and occasionally has a laxative effect.

The lungs and brain of sheep, and the liver of the ox are, in certain diseases, crowded with organisms; these are doubtless destroyed in cooking; moreover they do not appear to be able to exist in the human body, but are anyhow best avoided.

When the flesh of the pig has a mottled appearance this may be due to the presence of *trichina*; such pork must of course be condemned.

Various meats compared.—Besides the fluctuations in the proportions of protein, water and fat already discussed, the chief differences to be noticed between different meats, whether fish, flesh or fowl are:—

(1) Structural modifications in the muscular fibre, whereby the softness and digestibility are affected;
(2) variations in the amount of gelatin-yielding constituents;
(3) the extent of the alkaloidal principles present; and
(4) the proportion of albumin.

Age and variety of animal, its feeding and the time elapsed since killing are the main factors influencing toughness. Meat is tender before *rigor mortis* has

set in, but if the rigidity of the muscles has commenced, it will be necessary to keep the meat a few days before it becomes tender again.

Tough meat can only with difficulty be broken up by the teeth, whereas the smaller the particles entering the stomach the more rapid will be the dissolving action of the gastric juice.

Peptonisation of proteid tissues is greatly impeded when the fibres are surrounded with a substance like fat, which the gastric juice cannot dissolve. Fat, although a very necessary component of our diet, will give extra trouble to the stomach if *closely intermingled* either with animal or vegetable foods.

Hence intimate mixtures are difficult to digest.

Very fat pork is an example of the more indigestible kind of meat; and as typical of the more easily assimilated the flesh of young chickens might be cited.

Dryness is another objectionable feature—it partly accounts for the reputation which veal has acquired in this country. Dried meats, even though they may be long soaked in water before cooking, are never as digestible as the same meats undesiccated. The fibres are hardened by drying in such a way that it becomes exceedingly difficult to restore to them their original texture.

The proportion of muscular fibre is usually highest in the flesh of quadrupeds, lower in that of birds, and least in fish.

With respect to the amount of gelatin-yielding material no general rule can be given, but in most cases it is highest in young animals; pork, and veal too, are more gelatinous than beef and mutton, while this property is less marked in hare, rabbit, deer, fowl, duck and pigeon than in any of the ordinary butcher's

meats, a fact indicative of the superior nutritive value of poultry and game.

Another characteristic of these last-named classes of meats is their greater nerve-stimulating action, due to a rather larger amount of the meat bases.

MEAT EXTRACTS

The term 'Meat Extract' suggests to the general public a concentrated form of nourishment; to the medical practitioner it denotes a preparation that on occasion may be prescribed (some doctors, however, deny it a place in the sick-room dietary altogether); to the student of food chemistry or the analyst it is the more or less inappropriate designation for a product that enjoys a popularity based on misconceptions.

In only certain respects can meat extracts be considered concentrated :—

Firstly, in reference to the preposterous proportion of mineral matters which they contain;

Secondly, in regard to the amount of creatine and purine derivatives found in them.

Some enclose dissolved or peptonised proteids which, as we have seen, give to them a medicinal action unless used with caution; to others an addition of ground meat fibre has been made.

Let us take a typical 'meat extract,' one of the best on the market, and see how it compares with beef as a food.

One pound of beefsteak contains, even at a low estimate, 90 grm. of protein—nearly enough to supply a man of 11 stone with the flesh-formers he requires in 24 hours; it embodies no excess of salt and only

requires carbohydrate (say in the form of bread), to provide a full day's ration. The cost of the meat would be a shilling or thereabouts.

One pound of the meat extract would yield about 32 grm. of protein as ground meat fibre—most meat extracts are devoid of this addition; and 35 grm. of peptones or similar 'partly digested' proteids; total flesh-formers 67 grm. or about $\frac{2}{3}$ as much as in the meat. As a 4-oz. bottle costs 1s. 9d., we shall have to pay 10s. 6d. for 6 bottles, the equivalent of 1 lb. of meat. If we consumed this quantity of extract we should have absorbed at the same time a dangerous amount of nerve excitant, besides $3\frac{1}{2}$ oz. of common salt, apart from true meat salts.

Of course it would be impossible to take such an amount in one day; the meat extractives and peptones would produce serious intestinal and other disturbances, and the salt an intolerable thirst.

Even in the nearest approach to a concentrated 'meat extract'—a preparation sold in the form of compressed tablets, the total nutritive protein only equals that of lean beef, the balance being made up of meat bases, flavourings, mineral salts and indifferent substances.

The majority of meat extracts contain quite appreciable quantities of ammonia together with other odorous matters which become apparent to the olfactory sense in a far from agreeable manner when these products are dealt with in bulk.

In medicinal doses they may have value—mainly therapeutical—and in the kitchen they constitute flavourings, though very expensive ones; but the composition and properties of the commercial preparations known as 'meat extracts' prevent us deriving from

them more than an insignificant part of our nourishment; they cannot be truly regarded as foods in the commonly accepted interpretation of that word; far less as 'concentrated foods.'

Notwithstanding the general recognition of these facts by dieticians, the most extraordinary claims are made for certain of the advertised specialities of this class. We are told that by swallowing 1 oz. of, let us call it, 'Magic Meat Juice,' we may increase our weight by 10 to 20 oz. A University professor is quoted in substantiation of this startling assertion. It seems that this gentleman experimented with three dogs: in the case of one, which received 5 grm. of extract in addition to his ordinary amount of dog biscuit, his weight rose by 100 grm. ($3\frac{1}{2}$ oz.), while with one other dog the observed increase was 50 grm. When the dosing with extract ceased, the dogs' weights again became normal. From these experiments the professor concluded that the extract had both a direct and a very marked indirect nutritive value.

Let us consider what these experiments really mean. Observe, firstly, that the increases in weight are small weights, and remember that a live animal fluctuates in weight from hour to hour.

Secondly, the increase can only to a trifling degree represent meat extract—it must be due either to water or to dog biscuit; and since the biscuit was apparently properly digested by the animal when it had no meat extract, an increase in weight out of all proportion with the augmentation of ingested material means that metabolism is retarded, an undesirable condition of affairs from the dog's point of view (compare remarks on assimilation and metabolism, Chapter V). If you suddenly put on weight without your food having

been commensurately increased it is a very serious symptom.

But there is another consideration. Meat extracts contain much salt, and since, as we know, the salt concentration of the body fluids must be kept normal, the natural result of taking salt is that more water has to be retained in the system, and 1 part of salt requires about 100 parts of water to bring the fluids back to the right degree of dilution. (Meat extract creates thirst for this reason.) Later, of course, this excess is eliminated; but as long as the dogs receive a fresh dose of salt every day this elimination cannot be complete.

This, we think, affords a very simple explanation of what from all other aspects is paradoxical.

General range of composition of commercial meat extracts, meat juices and the like :—

Water	16	to 90	per cent.
Meat bases and extractives	3	,, 40	,, ,,
Peptonised protein (albumose, peptone, etc.)	3	,, 14	,, ,,
Meat fibre (ground)	nil	,, 7	,, ,,
Ammonia	0·12	,, 0·38	,, ,,
Salts	1	,, 29	,, ,,

(including common salt 0·3 to 14 per cent.)

SAUSAGES

The sausage might be one of the most nutritive of foods, it might also contain a scientifically balanced diet, but experience teaches us that the average commercial article fulfils neither of these conditions; in fact a wide gulf usually separates the ideal from the practically obtainable in this direction.

The common or everyday type of sausage is notoriously unsatisfying and is rightly viewed with suspicion.

Of course there are superior kinds, but they are exceptional. The aim of the unconscientious sausage-maker (and to him alone we are now referring) is to lower cost of manufacture as far as possible by the introduction of ' fillers ' containing the maximum of water.

Among ' filling ' materials are boiled rice (which, as is well known, holds a very large proportion of water), soaked bread, steamed potatoes and pounded veal. The last-named is a rather nauseating preparation made by pounding and re-pounding until reduced to a gluey consistency the flesh of a calf immediately after killing and before it has had time to cool ; after chopping up the pulpy mass so obtained it is mixed with its own weight of water, seasoned with salt and pepper, and treated with a little saltpetre to produce a fine red colour.

Boric acid and artificial blood colours are frequently employed in sausage factories.

Here is a formula recommended by a manufacturer [' The Manufacture of Sausages,' by J. C. Duff, New York, 1899].

Pork sausages :—

80 lb. pork trimmings.
16 ,, boiled rice.
2 ,, pigs' liver.
2 ,, unsmoked bacon.
Water to the desired consistency.
Seasoning :
22 oz. salt.
6 ,, white pepper.
1½ ,, cayenne pepper.
1 ,, ground nutmegs.
1 ,, ,, cloves.
1 ,, mace.
A little chopped sage, if desired.

Bread and fat enter very largely into the composition of many sausages, and the proportion of meat is sometimes reduced almost to the vanishing point.

Composition of genuine sausages :—

Water (natural moisture) . .	40 to 60 per cent.
Protein	12 ,, 18 ,, ,,
Fat	15 ,, 30 ,, ,,
Starch, etc. (Carbohydrates) . .	nil ,, 10 ,, ,,
Mineral salts	2 ,, 6 ,, ,,

PROPRIETARY PROTEIN FOODS

During the last decade or so there have appeared upon the market under fancy names such as plasmon, tropon, soson, roborate and so on, a variety of what may be called protein foods, which we group as follows :—

(1) Those consisting in the main of milk casein.
These are generally prepared from skimmed milk, an acid being used to throw out the casein, which is then washed and dried. To some brands an addition of bicarbonate of soda is made with the object of rendering the casein more easily soluble.

(2) Those derived from the waste meat fibre of meat-extract works by dissolving it in weak caustic soda, filtering the solution thus obtained, and subsequently re-precipitating the proteid matter by an acid.

(3) Those consisting mainly of vegetable gluten, often being the by-product of starch manufacture.

(4) Mixed proteid matters from one or other of the above sources.

Such preparations, mostly in the form of dry powder, do in effect contain a very large proportion of protein, so that by their aid it is possible to enrich other foods deficient in flesh-formers; their digestibility, too, judged from experiments extending over short periods, would appear to be quite satisfactory, but at the same time there are certain aspects of these food-stuffs which require careful consideration.

They are prepared by chemical means, and the chemical treatment is in some cases rather severe.

This treatment not only affects the chemical constitution of the proteid matters themselves but disturbs the ratio in which they stand to the mineral salts of the natural foods from which they are derived.

The addition of bicarbonate of soda to some of the casein preparations appears quite unnecessary. It cannot be beneficial to be continually consuming that salt.

Milk and milk products are deficient in iron, and therefore should not be made to take the place of other foods to too large an extent.

The price of the majority of these specialities is high.

CHAPTER IX

DAIRY PRODUCE, EGGS, ETC.

General remarks.—In this chapter are included two natural products of dietetic pre-eminence. On the one hand cows' milk—a liquid food designed by Nature to supply *all* the alimentary needs of a young animal, and found (modified) to be adaptable to those of the young infant; on the other hand eggs, which represent a young organism in its entirety—unformed and in a fluid state.

Both are whole-diet foods containing, in addition to mineral salts, a certain balance of protein to non-protein matter which justifies the unique place which these foods occupy in our alimentation.

In each the fat is in a most easily digestible form, that of milk being so extremely finely divided that a cubic inch of the fluid holds from 30,000 millions to 50,000 millions of fat globules, and yet the total weight of that huge number is less than 9 grains.

Butter and cheese too have special claims to dietetic recognition, the former being the most digestible of fats and the latter one of the most concentrated of foods, containing as it does $1\frac{1}{2}$ times as much protein as lean meat, and as much fat as protein; or, in all, 5 times the nutritive matter found in an equal weight of milk.

MILK

Thanks to the conditions of modern life, our infants, more and more deprived of their natural sustenance, are now artificially reared to such an extent that a diminution in the supply of cows' milk is at once reflected by a rise in infantile mortality, and a stoppage would not only decimate our infant population but jeopardise our future as a race.

While no longer altogether indispensable after the infant stage of existence has been passed, milk should enter liberally into the dietary of children of all ages, and, with a spread of dietetic knowledge, will, it is to be hoped, take a larger share in their nutrition in the future than it does at present.

Meanwhile we are confronted with this serious position, viz., that for 40 years the population has been increasing much faster than the milk supply.

The number of milch cows in the United Kingdom in 1910 was 4,360,620, which, at an average yield of 420 gallons (the estimate of Mr. W. Jackling at a lecture delivered at the Royal Institute of Public Health), provides sufficient for a daily allowance of 0·83 pint per head. The imports of condensed milk being close upon one million cwt. would represent another sixth of a pint of uncondensed milk—total: almost exactly one pint; but a notable proportion is used for feeding calves, etc., and a large part reaches us only in the form of butter and cheese. The real consumption of milk as such is estimated at not more than one-third of a pint per head, and as practically every adult consumes milk as an addition to tea, coffee, cocoa, or porridge, besides taking it as an

essential ingredient of milk-puddings, custards and so on, there is certainly not enough left to permit of every child receiving an adequate quantity.

The milk supply might be greatly increased with very material advantage to our children and ourselves, always assuming that the quality be irreproachable (a condition which is unfortunately difficult of attainment).

How greatly the nation's need of milk exceeds the home production is shown by our annual imports of some 30 million pounds' worth of what may be called milk educts, i.e., butter and cheese.

And yet the cow, as Prof. C. H. Eccles of the Department of Dairy Husbandry in the University of Wisconsin tells us, may be brought to a nearly incredible pitch of productiveness. He describes an animal of Holstein breed called 'Princess Carlotta' which in 12 months produced 18,405 lb. of milk containing solid nutrients weighing 2218 lb., or nearly one ton. This weight of solid nutritive food is equal to all the solid matter—eatable and uneatable, hide and all included—in 4 oxen.

MILK—FURTHER CONSIDERED

Composition and food value of milk.—There are both chemical and physical reasons for the special value of milk as a food; it presents us not only with members of each of the great classes of food principles—protein, fat and carbohydrate—in not very far from equal parts, besides bone-building mineral salts, but these are in such forms that while but little labour is thrown upon the digestive organs a maximum of availability is ensured.

The chemical composition of milk supplied to town

dwellers, that is to say the mixed milks of a herd of cows, is usually as follows :—

	per cent.		
Protein (casein[1] and albumin) . . .	3 to 4,	average	$3\frac{1}{2}$ per cent.
Fat (butter fat) . .	3 ,, 4	,,	$3\frac{1}{2}$,, ,,
Carbohydrate (milk sugar)	4 ,, 6	,,	5 ,, ,,
Mineral salts (as left on ignition) . . .	—	,,	0·7 ,, ,,
Water . . .	86 to 87	,,	87 ,, ,,
Specific gravity . .	1030 to 1032		
Food ratio . . .	1 to 4		

The Sale of Food and Drugs Acts fix the minimum limit for fat at 3 per cent., and that for non-fatty solids at $8\frac{1}{2}$ per cent., milk containing less than these amounts being regarded as adulterated, or 'not of the nature, substance and quality demanded.' It is true that the milk of individual cows is frequently weaker than the standard, and even the mixed milks of a herd may fall below the normal, but this is very rarely the case ; whereas a great majority of genuine milks exceed the limit very appreciably. Thus the average per cent. of fat in the milk supplied by one of the principal London dairy companies in 1910 was 3·6 per cent. for the morning milk and nearly 4 per cent. for evening milk, the total solids being 12·4 and 12·6 respectively.

'**Added water.**'—In this connection we would draw attention to the occasionally misleading expression, 'added water,' used in prosecutions against milk dealers. It really means 'water in excess of legal limit,' but whether derived from the cow herself or directly from the pump is not always shown, and in

[1] According to modern nomenclature, only the precipitated substance is called casein ; when in solution in milk it is 'caseinogen.' Casein is regarded as a lime phosphate compound of caseinogen.

some instances cannot be proved. Of course it denotes milk below normal quality, against the sale of which the public must be protected.

Physical composition of milk.—The physical as distinguished from the chemical characteristics of milk offer several interesting features, remarkable examples being afforded us of the various ways in which a solid substance may be intermingled with a fluid. The fat is in the condition of a 'suspension,' not really dissolved but finely divided, although not so finely as to prevent each particle or globule being discernible quite readily under a good microscope.

The albumin is in 'colloidal solution,' the particles being so fine as to be altogether invisible under the highest magnification, but nevertheless not so minute as in the case of a true solution, for the particles (or some of them) intercept light and in that way may be detected by an instrument called the ultra-microscope. The milk-sugar is in true solution, the particles being reduced to the ultimate molecules or very small aggregates of these. In the case of the casein, or rather caseinogen, the exact state is a little uncertain but may perhaps be best described as a pseudo-colloidal or unstable colloidal condition.

A little reflection will enable us to find reasons for these several conditions. Thus, while there is no physiological objection to sugar being presented to the stomach in true solution, it is otherwise with fat which cannot be dissolved in a neutral aqueous fluid; alkali will dissolve fat, but decomposition ensues and there results a soap which the stomach would not tolerate. Perfect solution of protein, too, is undesirable for various reasons (*cf.* remarks under 'Meat Extracts').

How to drink milk.—One need not be astonished to hear from persons who had been in the habit of swallowing milk in draughts, as if it were water, that having found it to disagree with them they have given up drinking it altogether. When consumed in this way large clots are liable to be formed as soon as the milk reaches the stomach (which is normally acid), but when *sipped*—as Nature intended—the result is quite different. It is also better digested when somewhat diluted either with soda water or plain water.

Being already charged with solid matters to the extent of 1 in 7 or 1 in 8, milk should not be made to serve as a drink in the ordinary sense of that word, that is to say as an aid to the digestion of solid food or to quench thirst—it is both food and beverage in itself.

Milk, though excellent, not necessarily the 'ideal food.'—Milk is sometimes referred to as the 'ideal food,' but in so far as its application to the feeding of adult human beings is concerned, that description rather exceeds the truth, and even for infants milk requires modifying.

Milk occupies an intermediate position between a drink and a solid food but is too nutritious for a beverage and too dilute to replace solid nourishment altogether; moreover, for use over a long period it is too rich in fat (in proportion to other constituents), too poor in iron, and too insipid. These shortcomings are mentioned as a caution against the exaggerated use of milk in the dietary of adults; its special functions—the enrichment of a diet otherwise poor in fat and protein, and, of course, the rearing of infants—remain unassailed.

Milk forms an invaluable component part of a general diet, but more should not be expected of it.

How to judge milk, and precautions to be taken in regard to it.—Since the fat in milk *lowers*, while the sugar and other solids *raise*, the specific gravity, that factor is not in itself an unfailing guide to the quality of milk ; nevertheless, it is a rough one within certain limits, and being easily ascertained, it is the most generally applied of all the milk tests, particularly by members of the public.

The simplest, although not a very accurate, way of determining the specific gravity of milk is by immersing in it a lactometer—a form of hydrometer—from which the gravity is directly read according to the depth to which it sinks in the fluid. (The lower the stem sinks, the lower the gravity, and *vice versâ*). The milk should be brought to the temperature—generally 60° F.—at which the instrument was intended to be used. In the laboratory more certain results are obtained with a 'Westphal balance,' or better, a pycnometer weighed upon a chemical balance.

Another easily observed character is the opacity ; a milk weak in fat is inclined to be too 'thin' and more transparent than usual, whereas less fluidity and greater opacity denote, as a general rule, richness in cream. A little device for gauging the opacity is now obtainable and furnishes fairly satisfactory results.

A measurement of the depth of cream formed after the milk has stood in a tall narrow graduated glass vessel—creamometer—supplies some information but is not always a reliable test.

The colour is a very misleading guide ; it is perhaps best to avoid that yellowish hue so popularly supposed

to indicate richness, for it is too often entirely artificial. Insist on undyed milk.

Milk freshly received into a chemically clean vessel from the equally clean udder of a perfectly healthy cow standing in hygienic surroundings and milked by a person with bacteriologically clean hands, who wears clothes from which fibres and dirt are not falling, may be entirely free from living organisms ; but how often are these conditions realised ? Never !

Until farm hands lose their indifference to dirt and their derisive attitude towards the microbe the difficulties in the way of the conscientious milk vendor will be immense.

Fortunately great progress is being made, and we may hope for still greater.

In the meanwhile we may adopt simple precautionary measures tending to remove adventitious impurities and to reduce risks from micro-organisms to a minimum or even to the vanishing point.

It is advisable to skim off and reject the upper film of the cream (even though a little of the latter be lost) and to throw away the last spoonful or so left at the bottom of any vessel from which milk has been decanted ; further, measures must be adopted to destroy any disease germs possibly present.

Living organisms in milk.—In the air we breathe and upon every object around us bacteria are nearly always to be found in great numbers ; so that, however carefully a dairyman's business may be carried on the complete exclusion of microbes from milk is not to be expected. On arrival at the London consumer's there are rarely less than a couple of million organisms to a cubic centimetre. [Dr. Wynter Blyth.] Harmless

as the great majority of these minute organisms undoubtedly are, means must be devised to keep their numbers down, for milk forms a medium specially favourable to their growth, and multiplication proceeds so rapidly that decomposition quickly ensues. In other words the milk 'goes bad.'

It is the lactic acid-forming bacteria which multiply most rapidly under ordinary circumstances; inconvenient though this may be in one respect—since the ever-increasing acidity soon curdles the milk—it is really a fortunate phenomenon; for the organisms referred to, as well as the acid they form, are not toxic, whereas other species which might be far more injurious are to a considerable extent 'crowded out.' Putrefactive organisms and disease germs are thus prevented from multiplying as fast as they would otherwise, but they are not killed, and should conditions arise more favourable to their growth and less so to the lactic bacteria—such conditions being met with in the human body—they may spring into activity.

There may be no pathogenic (disease-producing) organisms present, but without a bacteriological research we can never be sure.

BY BOILING THE MILK THE RISK OF MILK-BORNE DISEASES IS AVOIDED

For infant feeding there may or may not be drawbacks to a sterilised milk (this subject is discussed under 'Infant Feeding'), but for children other than infants, and for adults, there can be no question that the security afforded by sterilisation far outweighs in importance any of its possible drawbacks—dubious as they are.

Effects of heat upon microbes and milk.—The various

micro-organisms and their spores have different powers of resistance to heat, some being killed below 60° C. (140° F.) in a few minutes, others being able to withstand a higher temperature even than boiling water—at least for a short time. The living organisms are generally more readily killed than their spores.

In the following table, which shows the effect of heat upon a few typical microbes, the action upon certain milk constituents is also given :—

Sterilisation data :—

C.	F.	
52°	126·5°	Pneumococcus dies in 10 minutes.
56	133	Bacillus acidi lactici, ditto.
58	136·4	Bacillus typhosus ditto.
60	140	,, coli communis, ditto.
60	140	The rennin enzyme destroyed.
62	144	Most disease-producing bacteria die, but some of their spores resist one heating.
65	149	The tubercle bacillus has been known to live one hour at this degree of heat.
65·5	150	Vincent's pasteurisation temperature (15 minutes).
68	154·4	ALL MICRO-ORGANISMS DESTROYED but not all spores.
68·3	155	Freeman's pasteurisation temperature (30 minutes).
69·4	157	Leed's pasteurisation temperature (30 minutes).
72	161·6	Lactalbumin (chief whey proteid) coagulated.
75	167	Pasteurisation temperature: recommended for household use.
100	212	Water boils.
101	213·5	Milk boils.
105	221	Miquel's temperature for complete destruction of all germs in one hour's heating under pressure.
108	226·5	Ditto ditto—30 minutes.
110	230	Ditto ditto—15 minutes.

From this table we learn that organisms which produce disease succumb under a lower degree of heat than that needed to kill certain others, whereas to secure complete destruction of every spore as well as every organism in one heating—i.e., absolute sterilisation—a very high temperature is required, much above that of boiling water. This can only be attained by special high-pressure appliances such as are not generally to be found in the household.

Inasmuch, however, as the particularly resistant spores are not those which the householder has reason to fear—their presence only becoming objectionable when it is desired to keep the milk for a long period—there is no need to employ such drastic measures; a temperature of 75° C. (167° F.) maintained for half an hour is quite sufficient to safeguard against disease and not high enough to so seriously affect the chemical composition of the milk as to render it unfit for infants (except perhaps in a few cases in which the health or idiosyncrasy of the child contra-indicates the employment of heated milk of any kind).

Milk warmed to this comparatively gentle heat is termed 'pasteurised,' but if heated to the higher temperatures 'sterilised.' It should be remembered that according to circumstances a pasteurised milk may or may not be sterile, and a 'sterilised' milk is not always true to its name.

A milk or any other food remains sterile only so long as all chance of micro-organisms gaining access to it is prevented. A momentary removal of the stopper of a bottle of sterilised milk will undo the work of the steriliser.

Complete sterilisation without the use of great heat may be accomplished by threefold heating at a moderate

pasteurising temperature, an interval of from 24 to 48 hours being allowed to elapse between each operation. Since the lower temperature which suffices with the triple heating causes but little chemical change in the milk, this is a more scientific method than the single heating, but being too cumbersome for general use is only rarely adopted. The simpler system advocated above is to be preferred under all ordinary circumstances.

Cold as a preservative.—The speed of growth of micro-organisms falls almost to zero at the freezing point of water, but rises to a prodigious rate at a summer heat; hence to preserve milk or other food product as long as possible it should be kept in a cool place—refrigerator if available.

Chemical preservatives of every kind should be forbidden, for so far no chemical substance has yet been discovered which possesses active bactericidal properties without in any way affecting either the food-stuffs to which it is added or the human subject who consumes it. Hydrogen peroxide was at one time thought to fulfil this double rôle; it is often found, however, to disagreeably affect the flavour of the milk.

Boric acid and borates, perhaps the least harmful of chemical preservatives, are not altogether free from objection, and yet are very widely used in dairy products, notwithstanding the energetic attempts of public analysts to secure their illegality as components of foods.

Homogenised milk is milk in which the fat globules have been broken up by powerful mechanical means to such an extent that they no longer rise to the top on standing. When, as is usual, the milk is sterilised

after being homogenised or ' fixed ' in this way, it may be kept for weeks or longer without any fatty layer forming at the surface or any other change occurring (provided sterilisation be efficiently carried out). In consequence of the exceeding minuteness of the fatty particles in this milk it is more easily digested than ordinary milk.

Skimmed milk is of two kinds, either :—

Hand skimmed, i.e., deprived of the cream which had risen to the surface after some hours' standing, or

Machine skimmed—known also as *separated milk,* i.e., milk from which the fat has been separated by a centrifugal machine or separator.

As the mechanical treatment effects separation much more completely than the older hand process, the machine-skimmed product is poorer in fat than the other and, consequently, of somewhat lower nutritive value.

	Per cent. of Fat.
Hand-skimmed milk	0·75 to 1·0
Machine-skimmed milk (separated milk)	0·10 ,, 0·45

Except for infants, for which it is wholly unsuited, skimmed milk constitutes an economical food. If we assume—following Koenig's axiom—that protein, fat, and sugar have the relative money values five, three and one, we find that in lean meat at 1s. per lb., whole milk at 4d. per quart, and skimmed milk at 1d. per quart, the several food principles cost as follows :—

	Lean meat at 1s. per lb.		Whole milk at 4d. per qt.		Skimmed milk at 1d. per qt.	
	s.	*d.*	*s.*	*d.*	*s.*	*d.*
Flesh-formers cost per lb. .	5	0	2	0	0	8½
Fat	—		1	2	—	
Sugar	—		0	5	0	1½

Where the several food-stuffs are procurable at different prices than those named above, the cost of the components will be exactly proportional. Thus, if, as is true for certain localities, meat can be bought at 6d. per lb. the flesh-formers therein (supposing no fat or bone present) will cost 2s. 6d. per lb. In the above figures no count is taken of the small quantity of fat in skimmed milk.

As the ratio of protein to non-protein is high in skimmed milk, being about 1 to 1·4, it is useful for mixing with foods like bread, in which the proportion of flesh-formers is too low.

Standard for skimmed milk.—By the Sale of Milk Regulations skimmed milk is required to contain 9 per cent. (at least) of non-fatty solids.

Condensed milk.—The manufacture of condensed milk consists in the concentration in vacuum pans at as low a temperature as possible—generally about 50° C. (132° F.) of milk, whole or skimmed, with or without the addition of sugar.

It is very desirable that the several varieties of condensed milk should be carefully distinguished from each other; they are:—

(1) Concentrated whole milk unsweetened.
(2) ,, ,, ,, sweetened.
(3) ,, skimmed milk sweetened.
(4) ,, ,, ,, unsweetened.

This last form does not appear to be upon the market at present. The degree to which concentration is carried varies, but as a rough general rule it may be said that the volume of the original milk is brought

down to about one-third. The quantity of sugar added (before concentration) is usually large, namely from 30 to 50 per cent. of the finished product, so that the original ratio of milk constituents is greatly disturbed in sweetened condensed milks, and cannot of course be restored by dilution with water. The cost, when the added sugar is allowed for at market rates, is rather higher than that of fresh milk.

	Condensed sweetened whole milk. (1)		(2)		Fresh milk at 4d. per qt.	
	s.	d.	s.	d.	s.	d.
Milk solids as a whole, cost per lb. . . .	1	2	1	5	1	0⅘
Cane sugar, allowed for at	0	2½	0	2½	none	
Butter fat . . .	1	3⅔	1	7	1	2
Milk protein . .	2	3¼	2	9	2	0
Milk sugar . . .	0	5⅓	0	6½	0	5

(1) when sold at 5d. per tin containing net 15 oz.
(2) ,, ,, 3d. ,, ,, ,, 6¾ ,,

Against the extra cost the convenience of condensed milk must be placed.

In the case of condensed separated milk the value must be compared with fresh skimmed milk, which varies in cost in different localities.

	Skimmed Milks: Condensed sweetened. (3)		(4)		Fresh at 1d. per qt.		Fresh at 2d. per qt.	
	s.	d.	s.	d.	s.	d.	s.	d.
Milk solids, cost per lb.	1	8	1	0	0	4½	0	9
Cane sugar, allowed for at . . .	0	2½	0	2½	none		none	
Protein . . .	2	9¾	1	8⅓	0	8½	1	5
Milk sugar . .	0	6⅔	0	4	0	1½	0	3

Fat—not taken into account.

(3) When sold at 1d. per 3 oz. tin.
(4) ,, ,, 3d. ,, 15 ,,

Condensed skimmed milk is evidently far from economical.

Composition of commercial condensed milks:—

	Whole milk sweetened. per cent.	Whole milk unsweetened. per cent.	Skimmed sweetened. per cent.
Cane sugar . .	30 to 57	none	30 to 55
Milk sugar . .	13 ,, 17	16 to 18	12 ,, 18
Fat . . .	10 ,, 13	$9\frac{1}{2}$,, $12\frac{1}{2}$	0·2 ,, 1·3
Protein (albumin and casein) . .	8 ,, 12	8 ,, $14\frac{1}{2}$	7·5 ,, 12·5

There is no legal standard for condensed milk, but when required for ships' stores it must contain 10 per cent. of fat.

Condensed milk not sterile.—Previous to concentration the milk is usually 'sterilised,' but the method adopted does not appear to be quite effective; a few organisms originally present in the milk remain sometimes in the final product, while others find their way in during the filling of the tins. As a consequence, condensed milk is never sterile although very much freer from microbes than ordinary uncondensed milk.

No tubercle bacilli have been found in it, and it is almost invariably free from pathogenic germs in general. [Dr. Coutts' Report to the Local Government Board; also Prof. Delepine's researches.]

In undiluted condensed milk, micro-organisms do not grow readily, but on addition of water they multiply with extraordinary rapidity.

Extent of trade.—Apart from the condensed milk made in a few English and Irish factories, there was in 1909 nearly one million cwt. of condensed milk imported from abroad, rather over half this quantity being sweetened skimmed milk, the consumption of

which is growing at the expense of the corresponding product from whole milk.

Dried milk is now an important article of commerce, considerable quantities being consumed in the confectionery trades (for instance in the manufacture of milk chocolate); it is further used in place of condensed milk as an infant food.

A good dry milk, if made from whole milk, will contain :—

Water	4 to 6 per cent.
Fat	25 ,, 30 ,, ,,
Protein (casein, etc.) . . .	24 ,, 26 ,, ,,
Milk sugar (lactose) . . .	30 ,, 35 ,, ,,
Mineral salts	5 ,, 6 ,, ,,

If we mix 1 part of such milk with 6½ parts of water we shall have a fluid corresponding in concentration with fresh cows' milk, but differing from it somewhat in taste.

Dried skimmed milk—not to be used for infant feeding but a useful addition to many articles of food—should, if of good quality, contain in round figures :—

Water	4 to 6 per cent.
Fat	1 ,, 1½ ,, ,,
Protein	32 ,, 35 ,, ,,
Milk sugar	45 ,, 50 ,, ,,
Mineral salts	7 ,, 8 ,, ,,

To reduce this to the concentration of uncondensed skimmed milk, dilute 1 part with 10 of water.

Buttermilk, the fluid resulting from butter-making, has a composition akin to that of a skimmed milk, but soured by lactic fermentation, which has transformed

part of the milk sugar into lactic acid. It is credited with therapeutic virtues which, if existing, must be ascribed to the lactic ferments, but to drink it with comfort a trained palate is indispensable.

In the making of cakes, for which buttermilk is much favoured by housewives, the characteristic flavour seems to be of no importance, as it disappears in the cooking.

Whey.—When, for the purpose of cheese-making, rennet is added to milk, coagulation takes place; the casein which is thrown down—carrying most of the fat with it—forms the curd; and as no acidification has occurred, the fluid remaining is called 'sweet whey.' When, on the other hand, milk is allowed to become sour, spontaneously (i.e., by the agency of the lactic ferments) a curd is also formed, the liquid remaining in this case being 'sour whey.' A similar fluid may be made more expeditiously by the addition to fresh milk of a little acid such as lemon juice, tartaric acid, vinegar, etc.

Composition of whey:—

Water	93	to	93½	per	cent.
Protein	0·3	,,	1	,,	,,
Fat	0·1	,,	0·3	,,	,,
Lactose	4	,,	4¾	,,	,,
Salts	0·6	,,	0·8	,,	,,
Lactic acid	0·1	,,	0·4	,,	,,

Whey is much less nutritive than buttermilk, but finds a use in the adjustment of infant dietaries (q.v.) and as a weak fluid form of nourishment for persons suffering from certain fevers, etc.

Curd is the coagulum composed of casein, fat, etc., referred to under whey. It is the basis of cheese.

BUTTER

Fats, as explained in Chapter III, are compounds of glycerine with fatty acids—glycerides.

There is a complete series of fatty acids, beginning with volatile fluids (formic, acetic, propionic and butyric acids); then, among the middle members of the series, oily liquids insoluble in water; and, lastly, hard crystalline substances. The commonest of these acids, and those which are found in largest amount in all oils and fats (vegetable and animal), are oleic acid ($C_{18}H_{34}O_2$), an oily liquid, palmitic acid ($C_{16}H_{32}O_2$) and stearic acid ($C_{18}H_{36}O_2$), both these being crystalline solids at ordinary temperatures. Oleic acid congeals also if the temperature falls below about 57° C.

Milk fat contains glycerides of these same acids, but differs from other fats in holding larger proportions of the volatile fatty acids, particularly butyric acid ($C_4H_8O_2$). It is a complex mixture of glycerides.

Commercial butter consists of :—

Milk fat	82 to 86 per cent.
Water	10 ,, 16 ,, ,,
(more usually	12 ,, 16 ,, ,,)
Casein, milk sugar, mineral salts, etc.	1 ,, 2½ ,, ,,

In *salt butter* the added salt is from 1 to 3 per cent.

Digestibility.—The chemical constituents and physical properties of butter render it the most digestible of fats and the most widely tolerated, the average availability of butter being placed by Koenig at 97 per cent., the highest general availability figure for any food.

Fats have 2¼ times the calorific value of starch or

sugar, so that 1 oz. of butter, containing 84 per cent. of fat, will supply as much energy as 1·89, or nearly 2 oz., of starch or sugar.

Preservatives.—The least objectionable preservative of butter is common salt, but as this is not always to the taste of the consumer, the practice of using what are called chemical 'preservatives' such as boracic acid and borax is a very common one. Recent legislation restricts the employment of such preservatives to narrow limits.

Adulteration with other fats, particularly cocoanut oil and oleo-margarine, has been carried out on a large scale, and the utmost skill displayed in blending the ingredients so as to render their detection difficult.

The *micro-organisms in butter* are extremely numerous, from 60,000 to nearly 50,000,000 per gramme having been found at different times. The great majority are lactic bacteria, the remainder chiefly yeasts and moulds.

CHEESE

Preparation.—Cheese is prepared from the coagulum formed from milk, whole, partly skimmed, or enriched with cream, or even from cream entirely, when treated with rennet or acid, or allowed to sour spontaneously. Normally the precipitate or curd so obtained is drained, salted and left to ferment; if eaten fresh, it is known as cream cheese.

The *composition* of cheese varies somewhat widely according to the method of manufacture and the materials used, but for a normal ripened product,

made from whole milk, the variations will generally lie within the following limits :—

Whole-milk cheeses :—

Water	30 to 40 per cent.
Protein (casein, etc., etc.) .	20 ,, 30 ,, ,,
Fat	25 ,, 35 ,, ,,
Milk sugar . . .	traces ,, 3 ,, ,,
Mineral salts	3 ,, 6 ,, ,,

Such varieties as are made from enriched milk (milk plus cream) and known as 'double cream' necessarily contain a higher ratio of fat, namely, as much as 45 per cent., while those of the 'cream-cheese' class (unripened) are of a very variable nature.

Cream cheeses :—

Water	15 to 50 per cent.
Protein	8 ,, 20 ,, ,,
Fat	10 ,, 60 ,, ,,
Mineral salts	1 ,, 3 ,, ,,

If part of the cream is removed from the milk, or a mixture of whole and separated milks employed, the resulting cheese is of inferior quality, and on keeping, tends to become very hard—example Parmesan.

Ripening is the consequence of the activities of a variety of micro-organisms—yeasts, moulds and bacteria (notably lactic acid bacteria) which decompose most if not all of the sugar, a little of the fat and varying proportions of the proteids, the decomposition products of the latter being extraordinarily numerous.

Although the substances here named convey but little except to the specialist, and a description of such compounds would not be interesting, we mention in illustration of the complexity of the chemistry of cheese

that the following nitrogenous substances have been isolated from Emmentaler cheese by Bissegger:—

Alanine, leucine, isoleucine, phenyl-alanine, alpha-pyrrolidine-carboxylic, glutamic, asparagic and oxyalpha-pyrrolidine-carboxylic acids, serine, tyrosine, lysine, hystidine, tryptophan, ammonia, amino-valeric acid, caseo-glutin, tyro-albumin, peptones and tyrocasein.

This by no means exhausts the list, but will doubtless suffice.

Micro-organisms in cheese.—The number of micro-organisms in cheese has been found to vary from about one million to one thousand millions to the gramme (450,000,000 to 450,000,000,000 to the pound).

Properties.—The vastness of its microbial population and the heterogeneity of its chemical constituents might give rise to misgivings as to the wisdom of introducing cheese into the system, but if we consider the large consumption of this food among all peoples we can only conclude that no great harm can be effected either by the organisms or the decomposition products. The nature of the fermentative and other changes proceeding in the stomach and intestines is undoubtedly modified by cheese; there are many persons too who cannot digest it, but, given ordinary metabolic activity, cheese is assimilated very well (to the extent of about 90 per cent. of the total solids contained in it); in fact it not only constitutes a staple article of diet but one also of the most nutritious of foods.

One pound of cheese contains as much protein as 1½ lb. of lean meat; and 6 oz. of cheese with 24 oz. of bread would supply all the nutrients required in 24 hours by an average man of 11 stone.

Milks of animals other than cows.—After that of the cow, the only other animals' milks of any importance for human food are those of the goat, sheep, mare and ass.

There is a general similarity in the qualitative composition of all milks, but they differ one from another quantitatively; with the four kinds under consideration zoological kinship runs hand-in-hand with the chemical constitution to some extent, sheep and goats generally yielding a thick, rich milk; asses and mares a thinner one, poor in fat.

Against the lower nutritive value of the latter milks we have to set their greater digestibility; conversely, the higher nutritiousness of goats' milk is accompanied by a lower degree of digestibility. This is only to be taken as a rough general rule, digestibility being so much a matter of idiosyncrasy.

Asses' and mares' milks resemble human milk more closely than do the milks of either sheep or goats.

General range of composition:—

	Protein.	Fat.	Sugar.
Goats' milk .	$3\frac{1}{2}$ to $5\frac{1}{2}$	4 to 8	4 to 5 per cent.
Sheep's milk .	4 ,, 7	4 ,, 9	4 ,, 6 ,, ,,
Mares' ,, .	$1\frac{3}{4}$,, $2\frac{1}{4}$	1 ,, $1\frac{1}{2}$	5 ,, 7 ,, ,,
Asses' ,, .	$1\frac{1}{4}$,, $1\frac{3}{4}$	0·4 ,, 3	5 ,, 7 ,, ,,

Fermented milks.—See Beverages.

EGGS

Like milk, eggs form one of those articles of diet the larger production and consumption of which could not fail to be beneficial; their exceptional nutritive value has long been proverbial and many of their culinary uses well known, but they still occupy too subordinate a place upon our tables. The yolk of egg

in particular is a very valuable food, especially for growing children, by reason of its richness in protein, fat, lecithin, lime and phosphate.

Even if we grant the dietetic worth of eggs—as most of us do—we probably overlook the fact that they are not necessarily uneconomical, for 9 average eggs of $1\frac{3}{4}$ oz. each enclose as much nourishment as is contained in a pound of meat.

Productiveness of the hen.—A Buff Orpington at a recent competition laid in 16 weeks 103 eggs, weighing probably 13 lb., or $\frac{3}{4}$ of a pound of eggs per week. Balland, the great French food chemist, tells us that a Bresse fowl, an average, not a prize bird, will lay 160 eggs of 75 grammes (nearly $2\frac{3}{4}$ oz.), or 26 lb. of eggs in a year.

England imports annually 2000 million eggs.

Composition (egg without shell) :—

Water	72 to 75 per cent.
Protein	11 ,, $13\frac{1}{2}$,, ,,
Fat	11 ,, $13\frac{1}{2}$,, ,,
Extractives (non-nitrogenous) .	0·5 ,, $1\frac{1}{2}$,, ,,
Mineral salts	about 1 ,, ,,

The eggs of other birds have a very similar composition.

The white and the yolk differ greatly one from the other in chemical composition and nutritive value; the former is practically a solution of proteids (12 to $13\frac{1}{2}$ per cent.) in water (85 to 87 per cent.), with only trifling amounts of other substances; whereas the yolk contains roughly 50 per cent. of nutrients (proteids, etc., 15 to 18, fat 30 to 35, mineral salts 1 to $1\frac{1}{2}$ per cent.).

Special interest attaches to the *lipoids or fat-like*

bodies of egg yolk, namely cholesterin, lecithin, kephalin, etc., because these substances are abundant in brain and other nervous tissue, and are believed to influence growth. (The weight of an infant's brain is said to depend upon the lecithin contained in the milk upon which it has been fed).

Lecithin may be described as a phosphorised nitrogenous derivative of a fat; that is to say it is a fat plus phosphoric acid plus a nitrogenous base. It breaks up into glycero-phosphoric acid, choline (a compound ammonia) and fat. (A nervous breakdown leads to this decomposition, and choline appears in the blood and cerebro-spinal fluid.)

Kephalin, a wax-like substance with a constitution analogous with that of lecithin, is found in brain, egg yolk and nerve fibres.

Cholesterin, more widely distributed than the above, being present in small quantities in all animal fats, is also wax-like, but differs from lecithin or kephalin in being devoid of phosphorus or nitrogen. It is found in all forms of protoplasm, and is specially abundant in the sheath of nerve fibres.

Egg yolk contains other bodies of the same class.

The proteids of eggs are also important, the chief being albumin, or ovalbumin, the substance which forms the white coagulum when an egg is heated; ovomucin, a compound containing a sugar group in the molecule; and nucleo-vitellin, one of the nucleo-proteids, the composition of which has been described in Chapter III.

CHAPTER X

CEREALS, BREAD, ETC.

From the statistics of the Board of Trade we learn that wheaten bread and flour outweigh to a remarkable extent all other food-stuffs in the dietary of the great majority of the inhabitants of this country.

It would at first sight appear that the average Englishman is far more of a bread eater and much less carnivorous than he is usually supposed to be. The figures collated by the Department relate in the main to the food consumed by typical *families* rather than that eaten by individuals. It is common knowledge, however, that among the less well-favoured classes, the wife, feeling that the wage-earner must be kept 'fit' at all costs, carries out her praiseworthy object at the expense no doubt of her own health and, unconsciously perhaps, also of her children.

Too much bread?—So that if bread preponderates largely in the more or less theoretical individual diet got by dividing the family's supply over each member thereof, how much must this statistical preponderance fall short of the truth when we come to the women and children of the poor? Bread and potatoes, the chief component of which is starch, enter altogether too largely into their daily portion, which includes but a meagre quota of the richer protein foods so essential to the repair of tissue.

THE CEREALS IN GENERAL

The cultivated grasses, or cereals, most used for human food are wheat, barley, oats, rice, maize and rye; other grains much less widely consumed are millet, sorghum and buckwheat, the last-named not a cereal.

Wheat and rye alone among these yield flour possessing the character necessary for bread-making, and of the two, wheat is so far the better that in this country at least it has to a very large extent supplanted other cereals.

The oat, once the staple article of diet in many parts of the United Kingdom—particularly Scotland and Ireland—is rapidly sinking to a very subordinate position in the people's dietary; a fact which is to be deplored, because firstly, the higher ratio of tissue-building nutrients in oatmeal places it at the head of all the cereal flours, and secondly, the careful mastication necessary with the old-fashioned and almost vanished oatcake tended greatly to the preservation of the teeth and the health generally, whereas the modern custom of swallowing bread—it can scarcely be said to be masticated—has had the opposite effect.

A few Statistics upon the Consumption of Cereals

Wheat and wheaten flour imported and home grown in 1910 . .	147,500,000 cwt.
Wheat and wheaten flour consumed per head in U.K. . . .	358 lb.
(These figures are in excess of the truth as they include 'offal.')	
Great Britain's production of wheat in 1911 (Board of Trade estimate) .	33,500,000 cwt.

Wheat flour milled in United Kingdom	78,041,000	cwt.
In addition to offal . . .	37,901,000	,,
(‘ Census of Production,’ 1907.)		
Oatmeal ground in U.K. ditto ditto	2,060,000	,,
,, imported (allowance made for re-exports)	332,000	,,
Rolled oats imported . . .	286,000	,,
(Oatmeal offal and by-products not included, nor crushed oats, provender and feeding-stuffs for cattle.)		
Barley meal and flour ground in U.K.	6,065,000	,,
(Not including barley used in breweries.)		
Maize meal ground in U.K. . .	17,913,000	,,
,, ,, imported (allowance made for re-exports)	543,000	,,
Rice cleaned, milled or ground in U.K.	1,739,000	,,
Farinaceous preparations made in milling factories in U.K. (including pearl barley, rolled oats, etc.) .	342,000	,,
Total value of products milled in U.K.	£65,000,000	

The table on page 149 deals with the composition of the entire grain (excluding husk). Unfortunately, as our race is not gifted with the digestive powers of rodents or grain-eating herbivora, we cannot eat the whole grain, for much of the nutrients lying in the exterior parts are so encased in ligneous tissue as to elude the action of the human digestive ferments (see article on ‘ Bran ’). And as the nutritive principles are not evenly distributed throughout the grain there are differences in proportion observable when those portions which are used for food—mainly the interior parts—are compared with the grain as a whole.

The table on p. 150 shows the composition of flour and meal of various kinds.

Cereals—General Range of Composition of the Whole Grain

	Percentages					
	Water.	Protein.	Fat.	Starch, etc.	Fibre.	Ash.
Wheat	General Range 7 to 16 %	8 to 18[1]	0·3 to 2½	65 to 75	1¼ to 3¼	1½ to 2½
Barley		8 ,, 13	1¼ ,, 2¼	65 ,, 72	3 ,, 6	1¾ ,, 3
Oat (with husk)		7 ,, 18	2¼ ,, 7	57 ,, 64	7 ,, 12	2 ,, 6
Rye		7½ ,, 15	1 ,, 1½	69 ,, 76	1¼ ,, 2¼	1½ ,, 2¼
Maize		6 ,, 12	3 ,, 6	67 ,, 75	1 ,, 4	0·7 ,, 2
Rice (decorticated)		5½ ,, 9	0·2 ,, 0·7	75 ,, 81	0·2 ,, 0·4	0·2 ,, 0·6
Buckwheat[2]		9 ,, 13	1¾ ,, 2¾	56 ,, 65	8 ,, 13½	1½ ,, 3¼
Millet		9 ,, 16	2¼ ,, 6¼	60 ,, 71	1¼ ,, 4	0·8 ,, 2·0

General Averages

	Water.	Protein.	Fat.	Starch, etc.	Fibre.	Ash.
Wheat	General Average 13%	12	1½	71	2¼	1¾
Barley		10	1¾	67	4	2
Oat		13	4	59	10	3
Rye		11	1¼	70	2	2
Maize		9	1½	71	2½	1½
Rice (decorticated)		8	0·4	78	0·3	0·3
Buckwheat[2]		11	2	62	9	2
Millet		12	3½	64	2½	1½
Sorghum (durrha)		9	3	70	3	2

[1] So high a percentage for wheat is rare, except for durum wheat.
[2] Included here for convenience, although not a cereal.

CEREAL FLOUR, ETC.—GENERAL RANGE OF COMPOSITION

	PERCENTAGES.					
	Water.	Protein.	Fat.	Starch, etc.	Fibre.	Ash.
Wheat flour, patent .		8 to 12	0·4 to 1	72 to 79	0·15 to 0·35	0·3 to 0·4
„ „ household .		9 „ 12	1 „ 1½	70 „ 75	0·20 „ 1	0·4 „ 0·5
„ „ straight run		9 „ 12	1 „ 1½	62 „ 70	0·7 „ 1	0·4 „ 0·5
„ „ middlings .		10 „ 16	3 „ 5	60 „ 70	1 „ 3	2 „ 4
„ „ bran . .		12 „ 15	2 „ 4	48 „ 58	4 „ 7	4 „ 7
„ „ germ .		24 „ 28	7 „ 12	—	—	3 „ 4
Rye flour, best . .		4 „ 6	0·5 „ 1	77 to 82	0·1 to 0·7	0·5 „ 0·9
„ „ medium .		6 „ 9	1 „ 1½	72 „ 77	0·7 „ 1	1 „ 1½
„ „ dark . .		7 „ 12	1 „ 2	65 „ 74	1 „ 2	1½ „ 2½
„ „ bran, average		12	3	61	9	5
Barley flour, fine „		9	1½	75	0·5	1½
„ groats „		12	2½	70	1	2
„ ‘ offal ’ „		10 to 13	3 to 3½	50 to 64	5 to 15	2 to 6
Oatmeal, fine . .		12 „ 18	7 „ 11	50 „ 60	2 „ 8	2 „ 5
„ coarse . .		10 „ 15	3 „ 9	48 „ 55	—	—
„ bran, average		9	3	48	—	—
Oats, rolled . . .		7 to 10	5 to 11	—	—	—
Maize flour, average .		9	3	74	1	1
„ germ „ .		16	30	30	3	7
„ bran „ .		6	1	62	15	1
Rice meal (best) average		7	0·5	79	0·15	0·7
„ ‘ polished ’ grain .		8	0·5	78	0·5	0·8
Buckwheat flour . .		9	2	75	1	1
Sorghum (durrha) meal .		8 to 11	2 to 4	67 to 74	0·5 to 1½	0·4 to 2

Structure of cereal grain.—Wheat being typical of the cereals, a description of that grain will suffice for our purpose.

The white interior portion of a grain of corn consists of a species of open network of relatively large cells with very delicate walls of thin cellulose easily broken down into the fluff which forms one of the by-products of the milling operation. These cells are crowded with starch granules, together with a comparatively small proportion of protein (gluten, etc.).

	per cent.
This central or main part of the grain is termed the *endosperm*, and represents about of the whole grain.	80 to 85
At one end of the endosperm is the embryo or germ ; this portion—highly important, in fact essential, where germination and growth are concerned, and very rich in protein and other nitrogenous matters and fat—loses much of its interest from a dietetic point of view by reason of the fact that it constitutes so small a proportion of the grain, namely, about	1 to 2
Surrounding the endosperm and embryo there is a layer of cells, called the aleurone layer, charged with protein ; it forms about	3
Then, proceeding as before, from within outwards, we find—	
A hyaline membrane.	—
The testa, or spermoderm, dark in colour ; and lastly,	—
The three layers of the pericarp, named respectively endocarp, mesocarp and epicarp ; these three, with the testa, amount to from	13 to 18

Submitted to the action of the roller mill, which carries out a complex series of crushings, siftings and separations, the several parts of the grain are variously divided up into 'offal' (the technical name given to the bran and other inferior products) and a variety of grades of flour, as indicated in the next table (p. 153).

THE ROLLER MILL *V.* THE STONE MILL

THE VARIOUS GRADES OF FLOUR

In the design of the modern roller mill the principal object in view has been the separation as perfectly as possible of all the coloured parts of the grain from the white flour, and this object it attains in a far more efficient manner than the older stone mill ever could. This does not mean that the whitest flour is the most to be desired, for, on the contrary, as has been pointed out already, the demand for *excessive* whiteness involves some sacrifice of nutritive properties; but on the other hand a return to the stone mill would not be an unmixed blessing.

A stone mill, while being less efficient in the removal of dirt, may (and does) introduce stone grit, for the stones have to be 'set,' that is roughened, at regular periods, and particles of stone are being constantly rubbed off and mixed with the flour. Moreover, any grade of flour produced on a stone mill can be equally well turned out from a roller mill with its more perfectly adjustable equipment.

The various grades of flour.[1]—The various grades of flour referred to in the table may be defined as follows:

'Graham' flour—a whole meal; contains all the bran.

[1] See Dr. Hamill's Report.

Grinding of Wheat on Roller Mill

First stage: Cleaning from dirt

Second stage: Passage through 'break rollers,' yielding

Bran | 'Throughs'

Third stage: Sifting and grading of 'throughs,' yielding

Break flour | Coarse semolina | Fine semolina | Coarse middlings | Fine middlings

Fourth stage: Passage through purifiers, i.e., sifting and blowing of these products, yielding

Fluff, bran, etc. | Tailings (finer offal) | Purified semolina | Purified middlings

Fifth stage: Treatment with reduction rollers and centrifugals, yielding flour of various grades

Reduction flour from last roller at bottom of mill | 'Households' from intermediate rolls | Highest grade flour ('Patent') or 'Whites' from first roller at top of mill

Break flour → May be mixed with reduction flour

Bran → With pollard (finer bran) nearly 20 %

May be mixed with reduction flour → Break flour 10 % or more

'Households' from intermediate rolls: about 35 %

Highest grade flour: about 35 %

If mixed = 'straight run' or 'straight grade flour'

Nominally possesses a higher nutritive value than white flour, but actually a higher degree of indigestibility.

'*Entire flour.*'—Not quite as 'entire' as Graham flour. Contains part of the bran finely divided; varies greatly in quality.

'*Households*'—a lower grade than 'patents' than which it is less white. Contains a very small proportion of the branny particles finely divided. Really more nutritive than 'patents.'

'*Straight run*'—may be described as a mixture of households and 'patents,' and intermediate in value, commercial as well as nutritive.

'*Patents*'—the very whitest part of the grain.

By-products.—Among these are :—

Pollards Middlings or sharps Bran	Not ordinarily used for human food except when whole-meal is wanted.

These are the grosser particles which will not pass through the fine meshes of the sieves. Pollard and middlings make excellent cattle and poultry food.

BREAD

The manufacture of bread resolves itself into three essential stages :—

(1) Making a dough from flour, water and a little salt, and incorporating therewith some yeast.

(2) Allowing fermentation to proceed in the dough by keeping it in a warm place for some hours, during which the yeast attacks the saccharine matters present and evolves therefrom carbonic acid gas, which, becoming entangled in the dough, causes it to swell up.

(3) Baking the resulting spongy mass, whereby further distension occurs.

Proportions.—To one sack of flour (280 lb.) the amount of water used—depending upon the character of flour and the kind of bread to be made—varies from about 130 to 170 lb., the average being about 140 lb.; the salt for the same quantity of flour is from 2½ to 4 lb., and the yeast from 6 oz. to 4 lb. The longer the dough is to stand the smaller the quantity of yeast and *vice versâ*.

To hasten the action of the yeast a little malt extract, malt flour or glucose is frequently used.

Changes occurring during fermenting and baking of bread.—The chemical changes taking place during the fermentation and cooking of bread are not so profound as might be supposed. The starch, the main constituent, is but little affected by the yeast, and during cooking only a portion is converted into soluble substances of a gummy character (dextrin) and sugar; the greater part of the starch granules are more or less physically changed, that is to say the granules may be burst open and rendered more easily digestible, but are not converted into sugar or gum. It is a curious fact that after a loaf has been taken from the oven a slow and partial reversion from soluble to insoluble starch products occurs. The protein undergoes a considerable transformation during fermentation—soluble nitrogenous compounds arising from insoluble ones; but in the oven the contrary direction of change predominates, for in the finished bread most of the protein is in the insoluble form.

The temperature attained in the interior of a loaf during baking is but a degree or so above that of boiling

water, say 101° C. (213·8° F.)—water boiling at 100° C. (212° F.).

Chemical composition of bread :—

Water . . .	25 to 45 %	rarely more but occasionally up to 50 %; average about 35 %
Sugar . . .	0·5 ,, 4·5%	,, ,, 2 %
Woody fibre .	0·1 ,, 1 %	,, ,, 0·3%
Starch, dextrin, etc.	42 ,, 62 %	,, ,, 50 or 52%
Protein and other nitrogenous matters	5 ,, 8½ %	more usually 6 to 7 %
Fat . . .	trace ,, 1½ %	average about 0·7 %
Ash . . .	0·9 ,, 1½ %	,, ,, 1 %

Most bread contains a trace of alcohol, the amount separated by O. Pohl in 1906 [*Zt. ang. Chem.*] having been at the rate of ⅓ grain to the ounce, say 1 in 1300.

Special breads.—The desire to raise the proportion of protein and fat in bread has led to the manufacture of the several *Germ breads* now on the market. In these a relatively large amount of wheat germ is mixed with ordinary wheat flour; thus, in one of the well-known brands the ratio is about 1 part of wheat germ (previously specially treated) to 3 parts of wheat flour.

The resultant bread is dark in colour, not unpalatable, and contains some 10 per cent. of total nitrogenous matters (not all protein) instead of the 6 or 7 per cent. normally found in ordinary bread, but the price is too high.

Hovis, Daren and Turog breads belong to the class of 'germ breads.'

Bean-meal bread.—The introduction of pea or bean meal into bread in order to raise the proportion of protein—also used to make the flour look whiter—

cannot be recommended. All pulse flours require very long cooking to render them even moderately digestible; the time which may be sufficient to bake an ordinary loaf is far too short for pea or bean meal; hence bread containing it is liable to be dangerously indigestible.

Brown bread.—Brown bread may be defined as bread containing bran or branny particles from the outer part of the grain. Its relative value will be gathered from the succeeding paragraphs on Bran, Use of brown bread, Standard bread, etc.

See under oat and rye for breads made from those cereals.

Use of chemicals in place of yeast.—A considerable number of chemical substances have been used in place of yeast for 'raising' bread, the principle involved being the liberation of carbonic acid gas within the dough from a carbonate—generally sodium bicarbonate—and an acid substance like cream of tartar, the evolution of gas taking place partly as soon as water is added to the mixture and partly under the action of heat in the oven.

Inasmuch as the very intimate incorporation of the chemicals with the flour is essential to success, householders frequently prefer to buy this mixture ready prepared under the name of 'self-raising flour.'

While the continued use of bread containing baking powders cannot be deemed desirable, the occasional consumption of such bread appears unobjectionable.

N.B.—It is practically impossible to procure tartaric acid or cream of tartar perfectly free from traces of lead.

Formula for bread without yeast.—Kirkland, in that excellent work 'The Modern Baker,' gives the following recipe :—

Flour	5 lb.
Bicarbonate of soda . . .	1 oz.
Cream of tartar . . .	2 ,,
Lard	5 ,,
Sugar	3 ,,
Milk	2 pints.

Should water be used instead of milk, the sugar may be omitted, but milk is certainly preferable to water.

Bran as a food.—The virtues of bran have been much extolled. Learned professors experimenting with rodents have noted how well they have thriven upon it. Enterprising journalists seizing upon this observation have desired to force bran bread upon the community, ignoring the enormous difference between the digestive powers of creatures that are able to flourish upon garbage and the more restricted facilities provided by our own alimentary system. (In passing, we would express surprise that these enthusiasts should stop at bran. Why not straw as well? A zoologist could be found to point to the elephant as an animal that satisfies a considerable part of his prodigious requirements with that material. Perhaps this campaign is in preparation.)

The truth about bran.—Excellent as the outer coating of the bran may be for some purposes, the simple truth is that however finely bran may be ground the human subject is unable to unlock—except to a limited extent—the nutrients sealed up in its wood-like cells. It is perfectly true that it contains more protein than flour does, but not more digestible protein. Bread

containing bran is actually less nutritious than that which is free from it; but notwithstanding this quantitative inferiority in digestible nutrients, whole-meal, or preferably 'nearly' whole-meal, is by no means to be condemned. On the contrary, its use occasionally, or even frequently, may—for the undermentioned reasons—be beneficial, but the consumer should know that a pound of such bread does not supply him with more protein and starch than the same weight of white bread, but less.

Use of brown bread.—There are reasons for believing that the substitution of 'nearly' whole-meal for part at least of the white variety so largely consumed hitherto may be advantageous in some directions :—

Firstly, variety in food is generally to be commended.

Secondly, the outer parts of the grain are richer in mineral salts than the interior portions which yield the whitest flour. It is not yet proved to what extent these mineral compounds are really needed. To adults they may not be required, and to elderly persons they may be objectionable—science is on uncertain ground in this matter—but to the growing child or the expectant mother they may provide mineral material for the building of bone, etc.

All breads deficient in lime.—In this connection we must particularly note, however, that breads of all kinds, white or brown, and in fact cereals generally, are poor in lime—that essential component of bone. The casein of milk will supply that base, and should therefore be used liberally in the cases indicated. For it is not enough that phosphorus compounds be abundant; imperfectly formed bone might still result were lime not forthcoming in adequate proportion.

Potash and lime are higher in quantity in the finest flour than in lower grades or in bran.

Thirdly, there is the possible advantage to the teeth ; according to some authorities brown bread, being less adherent, the probability of particles remaining attached to the teeth and affording food for bacteria which destroy them is also less. There is, further, the tendency to masticate it more thoroughly than is done with white bread.

(The superiority over any bread of a food needing careful mastication has been already insisted on.)

Caution.—Persons with sensitive digestion should proceed cautiously with foods containing branny fragments.

Simple test for whole-meal breads.—Allow a small portion to soak in hot water ; stir up till reduced to a thin cream ; pour gradually upon a piece of fine copper gauze of say 80 meshes to the linear inch, washing or gently brushing the gauze till nothing further passes through. All gross particles are in this way collected, and by always taking the same weight of bread each time the tests may be made strictly comparative. Some rather startling results are occasionally obtained in this manner (see 'Breakfast foods').

Standard bread (so called).—In regard to the proposal to 'standardise' bread by insisting that the flour from which it is made shall constitute 80 per cent. of the grain, instructive remarks are made by Dr. J. M. Hamill in his Report to the Local Government Board on the nutritive values of breads as follows: 'The definition in which so-called "standard" flour is described as "80 per cent. of the wheat with all the

germ and semolina" is unsatisfactory for more reasons than one. In the first place the term semolina does not connote any particular part of the grain; it is merely a trade name for the coarser fragments of endosperm produced in the break roller system, and is, therefore, incapable of exact definition. In the second place the requirement that the flour shall contain 80 per cent. of the wheat grain is by no means satisfactory as a "standard" of quality or composition. Wheats differ considerably one from another, and the skin or branny envelope bears a smaller ratio to the endosperm in the case of a large grain than of a small grain. Thus, in certain small grained wheats, such as some Russian wheat, the proportion of skin to endosperm is large, and it is not possible to obtain more than 60 per cent. of such grain as ordinary flour. Obviously, therefore, an 80 per cent. product from a wheat of this type would contain considerably more "offal" than an 80 per cent. product from a larger-grained wheat, which would yield 70 per cent. of ordinary flour.'

He shows that in flours from the same wheats the differences in protein and mineral matter between the 'standard' (80 per cent.) flours and the 'household' flours are comparatively small (even supposing digestibility to be the same, a supposition which he elsewhere shows to be not warranted).

A better aim?—Full credit must be accorded to those who aim at rendering the nation's bread dietetically better by keeping in it a larger proportion of the outer part of the grain, but as long as wheat is grown to please the eye of the baker or consumer irrespective of intrinsic value we shall not raise the tissue-forming constituents very much.

Instead of selection having proceeded in that direction, the guiding star of the agriculturist has been either yield per acre or the bakery criterion—the largest number of the most showy loaves that can be got from a sack of flour. (Of course the consumer must take his share of blame for this state of affairs.)

The grain which is richest in protein does not necessarily make the nicest-looking loaf. It is, however, A HIGH STANDARD OF PROTEIN that we need, not a high yield of loaves. Even without waiting for agricultural novelties our needs could be met, for there are already flours existing with very large proportions of tissue-building components. Thus Le Clere and Levitt [International Congress of Applied Chemistry, London, 1909] examined some Kansas wheat containing 22·3 per cent. of protein ; then we have the durum wheat (*Triticum durum*), grown in the countries bordering the Mediterranean, and in S. Russia ; this variety, used in the manufacture of macaroni, holds nearly as much at times as the variety just referred to.

Bread from such flour would be almost like bread and meat together.

Durum wheat gives a yellowish bread but of good flavour ; it is not a baker's ideal flour, however.

Milk bread.—The use of skimmed milk in place of water in the making of bread is a practice that ought to be more widely followed, since not only is the nutritive ratio improved—the protein being raised by as much as one-sixth, i.e., from say 6½ to 7½ per cent.—but lime compounds are introduced, and these, as we have seen, are normally deficient in bread.

The reader is warned that bread is occasionally sold as ' milk bread,' which contains no milk.

Macaroni and Italian pastes are made from special flours which are richer in nitrogenous matters than those generally employed for bread-making; thus, whereas ordinary flour contains on the average 8 to 10 per cent. of protein (and only exceptionally from 10 to 12), the proportion in Italian pastes is usually from 11 to 12½ per cent. They are therefore deserving of a more prominent place among cereals in the British household than they at present occupy.

Digestibility of bread.—In conformity with the general rule that the degree of availability of vegetable foods is lower than that of animal foods, we find from the results of a very large number of experiments that have been carried out in Europe and the United States, that whereas the protein of meat is on the average digestible to the extent of 97½ per cent., the digestibility of the protein matters of bread is only 75 to 84 per cent. (average about 80) for the finest white bread, and 70 to 75 per cent. (average about 73) for brown bread.

The starch is more readily assimilated, viz., to the extent of about 98 per cent. in best white bread and 92 per cent. in whole-meal.

Although the amount of branny matter in a medium quality bread may be quite small, its presence nevertheless exerts a marked effect, for its irritant action upon the intestine causes the whole contents of that organ to be more hurriedly discharged. This can of course only be an advantage when peristaltic action is sluggish; in cases of normal intestinal activity such stimulus is unnecessary, and in hypersensitiveness distinctly objectionable.

Bleaching of flour.—It is extraordinary to find leading scientists defending the bleaching of flour. A large

number of patents have been granted, and among the substances proposed and actually used for decolorising flour and wheat are some of the most powerfully corrosive gases that can be prepared in the chemist's laboratory; for example, nitric acid vapours, nitrosyl chloride, nitrogen peroxide, phosphorus chlorides, chlorine, ozone, etc. The justification put forward is that such a small quantity is employed that it can do no harm. It is a poor defence, and one that is not supported by direct evidence. Ladd, Bassett and White [*Chemical News*, 1909, 110-136] prove that toxic compounds are formed in the flour and digestibility injuriously affected. This is only what one would naturally infer from a knowledge of the properties of the reagents named.

Except to discriminate between what is clean and what is contaminated by dirt, or between a flour that contains bran and one that does not, colour in itself is one of the least important criteria; nutritive value and flavour is all that matters. Bleached flour should not be tolerated upon any pretext.

Why are chemical bleaching agents used? Not to make the flour better—they really make it worse; but to make it *look* better, which is to deceive the eye.

The oat is superior to wheat in some respects and inferior in others. It is richer in protein and fat, but contains more fibre and requires longer cooking than corresponding wheaten products.

That it cannot be made into bread is really an advantage (see comment under 'Cereals in General').

When made into porridge, oatmeal should be boiled with milk or milk and water for several hours. The

longer boiled the better it is digested; even 8 hours is not too long, although hardly necessary.

The double saucepans in which porridge is often made are not free from faults, the chief being that when water is boiled in the outer vessel the temperature reached in the inner one is not sufficient. A temperature rather above that of boiling water is desirable for perfect cooking of this food and may be attained in several ways :—

(1) In the single saucepan over the side of the fire or oven plate, the position of the vessel being shifted until a spot has been found where the heat is sufficient to keep the contents gently simmering without burning on the bottom. (Of course the mass must be stirred from time to time.)

(2) In a double saucepan, the outer being charged with salt solution so as to get a higher temperature than boiling water.

(3) By boiling under pressure.

N.B.—Rolled oats containing oat-bran are necessarily less digestible than oatmeal free (or nearly free) from bran, and unlike wheat and rye, the bran in the case of the oat is not richer in protein than the inner portions of the grain.

Bread containing oatmeal.—Although bread cannot be made from oatmeal alone, a nutritious loaf may be prepared from a mixture of wheat flour and oatmeal in equal parts.

Oat cakes and oat biscuits can very well be made without admixture with wheaten products, but never-

theless what are sold as such are often made from a mixture of the two cereals. The very large amount of fat frequently introduced into biscuits of this character (and found in other kinds too) restricts their use, and therefore the practice cannot be recommended. More than 20 per cent. of fat is not an uncommon proportion!

Rye.—The difference in composition between the interior and the outer parts of the grain, so marked in the case of wheat, is even greater in rye. The whitest, or 'best,' rye flour is very much poorer in protein than is the whitest wheaten flour; the outer portions of the grain yield a dark-coloured meal that may contain 2½ times as much protein as flour from the centre of the grain, but against this we have to set the very high degree of indigestibility.

Thus, researches by E. Romberg (16 experiments), Pannewitz (3 experiments) and H. Poda (3 experiments) showed that in fine rye flour (20 per cent. of the grain rejected) 30 per cent. of the protein was not digestible; in medium rye flour (15 per cent. of the grain rejected) 22 to 41 (average 32 per cent.) was not digested; in decorticated or whole-meal rye meal (Pumpernickel) 30 to 52 (average 40 per cent.) of the protein was not digested.

In this respect the coarsest wheat meal is but little inferior to the best rye flour.

We see that very little can be said in favour of rye bread, its widespread consumption in Northern regions being a question of expediency; it is eaten '*faute de mieux*.'

Russian rye, like Russian wheat, is usually richer in protein than that from other parts of Europe.

Maize or Indian corn.—This—the characteristic cereal of America and one of the most valuable crops of the United States—constitutes the staple food of the labouring and coloured populations in both the United States and South Africa.

It is more starchy and less nitrogenous than wheat, oats or rye, so that maize products can only safely take a large share in a dietary when other foods rich in protein are also consumed.

(For composition of maize see 'General Tables of Cereals and Cereal Flours.')

It should be noted that in the preparation of '*corn-flour*' the meal is deprived of much of its protein and fat by washing in water, so that the product contains practically little else but starch. It must therefore be enriched by admixture with milk and eggs (not 'egg powders,' which are innocent of eggs).

Digestibility.—Maize flour has about the same degree of availability as white wheaten flour—about 10 to 15 per cent. of the protein is usually undigested.

Barley.—Except for its special rôle in brewing, barley has fallen from the position it formerly occupied in the nutrition of human beings. Once a component part of bread and biscuits, we meet it at present only in our soups as 'pearl barley' or in the sick room as 'prepared groats' and as barley water.

Since in nutritive value barley is behind wheat, oats and rye (see 'Table of Cereals') we need not regret that it has been supplanted by one or other of these.

Rice.—This cereal, an essentially tropical one, enters very largely into the food of Asiatic races; but the

frequently-made assertion that such peoples ' live on rice ' is an exaggeration. No human being could live in health for any lengthy period on rice alone : the low percentage of nitrogen in the grain renders enrichment of the diet with leguminous or other food rich in that element absolutely indispensable, and it is always found that this practice is unconsciously followed.

Over-indulgence in rice leads to the disease called ' beri-beri,' which it is said may be avoided by the use of unpeeled grain, and upon this observation the deduction has been drawn that we ought to eat bran. But no person whose diet shows a proper balance will get beri-beri, whether his rice be peeled or unpeeled, and wheat eaters do not appear to be subject to the disease at all—in temperate regions at any rate.

Rice is frequently artificially ' faced ' with mineral matters such as powdered talc, and also with mineral oil. Excessive glossiness should therefore be viewed with suspicion.

Buckwheat, millet and sorghum.—These grains—the first-named not really a wheat, nor even a cereal—are of little interest to the Britisher, but are consumed in large quantities in various parts of the world.

Buckwheat cakes were at one time popular in England, and are still largely eaten on the Continent, in S. Africa, India and China.

Millet, much grown in India as well as in several European countries (France, Italy, Switzerland and parts of Germany), merits some attention because it equals wheat in nutritive value. A peculiarity of this

cereal is the large proportion of silica contained in it—45 to 50 per cent. of the mineral ash obtained on ignition of the grain.

Sorghum, grown in this country as a forage plant, yields a grain much used for bread-making in Central Africa, India and Southern Europe. It is rather less nutritive than wheat.

BREAKFAST FOODS

Under registered titles—sometimes as fanciful as the claims made for the specialities to which they have been assigned—a variety of cereal 'breakfast foods' have been introduced of recent times to the public.

They are of divers forms—powdered, granulated, flaked, malted, unmalted, cooked, partly cooked or uncooked—but in nearly all cases their appearance on the market is heralded as the commencement of a new epoch; literary and artistic ability of a high order are displayed in the propaganda with which their sale is supported, and the public is asked to believe that nothing approaching the particular product in nutritive and restorative properties has ever before been within their grasp.

Many of the most widely known of these preparations hail from the United States, and it is only just that the cool judgment of analytical experts should have been most prominently brought to bear upon them in that country. From the reports of the United States Department of Agriculture, the researches of Prof. Robert Harcourt and others, the composition of the proprietary 'breakfast foods' has been found to range between the following figures, by the side of

which are placed the average composition of wheat flour :—

	Proprietary Breakfast Foods. per cent.	Ordinary Wheat Flour. per cent.
Water	$7\frac{3}{4}$ to $12\frac{1}{4}$ (1)	10 to 15
Protein	$7\frac{1}{4}$ (2) ,, $14\frac{1}{2}$	8 ,, 12
Fat	trace ,, $6\frac{2}{3}$ (3)	0·4 ,, 1
Carbohydrates (starch, sugar, gum and fibre) (4)	70 ,, 80 (3)	62 ,, 79
Fibre (not determined in all the preparations) .	0·5 ,, 2	0·15 ,, 1
Ash	0·35 ,, 2·8	0·3 ,, 0·5

(1) Water generally about 10 per cent.
(2) Flaked rice was the lowest in protein and fat.
(3) The highest figures for fat and carbohydrate were obtained with granulated oats.
(4) Of the carbohydrates a considerable proportion in the case of malted preparations is soluble in water. Soluble carbohydrates (sugar and dextrin) ranged from 6 to 44 per cent. in a special malted food.

It is evident that when a proprietary 'breakfast food' is wholly a cereal product (which is nearly invariably the case) its nutritive value cannot differ very greatly from other cereal products that are not proprietary.

The malting process to which some have been submitted reduces the digestive work upon the starch, but except for some invalids it is very doubtful whether this is an advantage. (We do not increase our energies by abstaining from work.) The ratio of protein to non-protein remains the same as before.

In some of the granulated foods there is often a considerable amount of coarse fibre which is by no means conducive to ready digestion. An ounce of good quality oatmeal contains more nutriment than one ounce of the generality of these fancy preparations, and when well cooked is usually digested without

difficulty. In regard to the desirability of longer cooking than ordinarily given to oat or other meal—reference to which was made under 'Oats'—the following results obtained by Professor Harcourt are instructive :—

Influence of cooking on solubility :—

	Percentage of Soluble Matters	
	Rolled oats.	Wheat flour.
Uncooked	8·4	7 (nearly)
Cooked 20 minutes	15 (nearly)	27
,, 2 hours	18	37
,, 5 ,,	30	38
,, 8 ,,	34	40 (nearly)

From this it would at first sight appear that wheat products are more quickly affected by the action of boiling water than is the case with oats, but it must be remembered that the one (the wheat) was in the form of flour while the other was in flakes.

BISCUITS

The great possibilities of a biscuit are rarely if ever realised. Instead of the over-sweetened, superfatted article that so appeals to the taste of a child—whose appetite it destroys—a biscuit might be so adjusted in composition as to satisfy the normal nutritive ratio—a whole-diet food that would feed, not tickle or cloy the palate.

As it is, we have to treat biscuits as a very unimportant article of diet, very deficient in flesh-forming compounds and overcharged with sugar, starch, fat and flavourings.

There are a few exceptions to the above description, but where the nutritive value has been raised by introduction of materials rich in protein the price has

too frequently been raised in a still higher ratio. The ordinary range of composition of biscuits commonly found in the market is as follows :—

	per cent.
Water . . . . . . (usually under 10%)	1 to 12
Sugar	5 ,, 35
Fibre	0·15 ,, 1
Other Carbohydrates (starch, etc.) .	40 ,, 80
Protein	4 ,, 14
Fat	2 ,, 22
Mineral salts	0·8 ,, $1\frac{1}{2}$

Some rather curious compositions have on occasion figured as biscuits ; thus, a patent taken out a few years ago claimed among other materials the use in biscuit-making of ground bones, dried blood, and brewers' grains (exhausted malt).

The German army wheaten biscuit made from 70 per cent. flour (i.e. 30 per cent. of the grain removed) with addition of 1 part of salt, $2\frac{2}{3}$ parts caraway and $1\frac{1}{2}$ parts of yeast to every 100 parts of flour is found to range in composition as follows (Koenig's ' Nahrungs- und Genussmittel ') : Water 2·7 to 9·4, protein 9 to $10\frac{1}{3}$, fat 0·4 to 2·6, starch and other carbohydrates $78\frac{1}{2}$ to 81·7, ash 2·2 to 3 per cent.

An example of a *whole-diet biscuit* is afforded by the German army meat-biscuit made from :—

Wheaten flour	80·83 parts.
Lean minced meat, without fat or sinews	88·58 ,,
Bacon fat	5·54 ,,
Salt	1·12 ,,
Caraway	0·12 ,,
Yeast	2·21 ,,
Water	8·85 ,,

After cooking, the composition is, on the average (Koenig, *loc. cit.*) : Water 2·7, protein 24·9, fat 5·4, starch, etc., 64·6, ash 2·3 (of which 0·7 is common salt).

The proportion of meat being very large, the food ratio of this biscuit (1 of protein to 3·0 of starch equivalent) is such that other food less rich in nitrogen —the wheaten biscuit for instance—could be eaten with it without reducing the ratio of protein to too low a level.

Pastry.—See 'Confectionery, etc.,' Chapter XVI.

CHAPTER XI

LEGUMINOUS FOODS OR PULSES

The power possessed by plants of the botanical order *leguminosæ*—the pea and bean family—of directly fixing the nitrogen of the air explains their exceptional richness in nitrogenous compounds, in particular proteids, and raises them above the generality of vegetables in nutritive value.

In the dry state peas and beans contain, in addition to a plentiful supply of starch, as high a proportion of flesh-formers as flesh itself (undried), in one or two instances even twice as much ; so that the cereals are quite poor in comparison with them.

This fact, discovered by native races in many parts of the world, has led to a wide use of leguminous foods.

Highly nutritious as they are, a too free indulgence in the pulses, notwithstanding the most careful cooking, may be attended by certain inconveniences, for it cannot be denied that except with persons of vigorous constitution leading healthy out-door lives the lower rate of assimilability of these foods entails indigestion, with such concomitant discomforts as flatulence.

This drawback, which may pass unnoticed where the amount consumed represents but a fraction of the whole dietary, or where the constitutional vigour is of a high order, should be carefully considered where these conditions are not fulfilled.

Although the pulses are the sheet-anchor of the vegetarian they must be shunned by the dyspeptic.

In some experiments in which 250 grammes ($8\frac{3}{4}$ oz.) of beans were cooked and eaten daily with the skins, Strumpell found 40 per cent. of the protein escaped digestion, but when lentil flour was made up with milk and eggs all but 8·2 per cent. of the protein was digested.

Rubner found that a man taking no other food could digest as much as 83 per cent. of the protein of such a large dose as a kilo ($17\frac{1}{2}$ oz.) of peas (weighed dry before cooking), but only for a few days.

The liability to flatulence was observed in all cases.

Mary Ninman Abel, in a very interesting survey of the leguminous foods (Farmers' Bulletin, No. 121 of the U.S. Dept. Agric., Washington, 1900), concludes as follows :—

> 'The green or immature pea or bean are among our most valuable green vegetables. . . . The value of the dried pea, bean or lentil is such that one or more representatives are found in every country as a staple food, and they have been used from the earliest times. They are especially rich in protein . . . and are thus fitted to take the place of part of the meat in any dietary. In comparison with their value their price is low. . . . Must be considered next in importance to bread. Compared with cereals, legumes are (1) less completely digested if eaten in considerable quantity ; (2) it is improbable that they can be made into any form of palatable bread ; (3) their flavour is less generally liked, and on that account they will not be made

a regular daily food except by people who are forced to it. In view of their low cost and high nutritive value they may be used to larger extent than now.'

The necessity for care in the preparation of these foods is specially emphasised. Dried legumes, even after 8 hours' soaking in cold water, require long boiling, say one hour and a half; they are then usually sufficiently soft to be pressed through a sieve, though hard grains may still be found.

The skins of peas and beans that have been dried should be removed, for they pass through the intestines unchanged.

Soft water should be used in preference to hard water, as insoluble lime compounds are formed with the protein 'legumin.'

Composition of dried leguminous seeds.—In the proportion of protein, starch and moisture the species of peas, beans, etc., named below resemble each other closely, the general average range of composition being :—

Water	10 to 14 per cent.
Protein	18 ,, 23 ,, ,,
Starch with small quantities of sugar, etc.	48 ,, 65 ,, ,,
Fibre	2 ,, 7 ,, ,,
Mineral salts	2½ ,, 6 ,, ,,

This applies to—

French haricot or kidney bean (*Phaseolus vulgaris*).
Moon or Lima bean (*Phaseolus lunatus*).
Frijole or Mexican bean (*Phaseolus sp.*).
Lablab bean (*Dolichos lablab*).
Garden pea (*Pisum sativum*).
Chick pea (*Cicer arietinum*).

In the lentil (*Lens esculenta*), the Vigna bean or Cowpea (*Vigna catjang*) and the Fetish bean (*Canavalia ensiformis*) the proportion of protein may reach 26 or 28 per cent., while in the Lupin as much as 52 per cent. of nitrogenous compounds has been found, not all of which, however, is protein.

The pea-nut (*Arachis hypogæa*) and Soy bean (*Glycine hispida*) belong to the *leguminosæ* and are very rich in nitrogen, but being oily are included among oily seeds and nuts.

The locust, or St. John's bread (*Ceratonia siliqua*), although of the same botanical order, forms an exception to the general rule, being quite poor in protein—some 6 per cent. or so—the principal constituent being sugar, which may amount to 75 per cent. It belongs to the dried fruits (q.v.).

Composition of fresh (undried) leguminous vegetables. —In the green state the special richness of the *leguminosæ* is less striking; only when they are compared with other green vegetables does it become apparent; the usual range for peas and beans is as follows:—

	French beans green, with pod. per cent.	Green peas without pod. per cent.
Water	80 to 90	73 to 84
Protein	2 ,, 4	4 ,, 8
Pectin, sugar and other carbohydrates	4 ,, 8	8 ,, 16
Fibre	1 ,, 2	1½ ,, 2½
Fat	traces	traces
Mineral salts	0·3 to 1	0·5 to 1·2

CHAPTER XII

STARCHY SEEDS (OTHER THAN LEGUMES), NUTS, ROOTS, PREPARED STARCHES, ETC.

Of starchy seeds, the most nutritious are the legumes already dealt with, but we find in this section several very important food-stuffs—chiefly roots, tubers or products therefrom.

Potatoes.—After the cereals, potatoes take the largest share in the food of the people, not only in this country but in many others. Thus from the Board of Trade Reports we learn that the typical British working man's family consumes weekly

32 lb. of bread and flour and
17 lb. of potatoes,

the sum total of all other articles of diet being together but little more in weight than the potatoes alone.

Dried potatoes, as yet but little known here, are prepared in enormous and increasing quantities in Germany, where they are sold in the form of meal and flakes. (Some 800,000 cwt. were sold there in 1907.)

Like the rest of the starchy foods in this class, potatoes are very deficient in protein and nearly destitute of fat.

The yam, or sweet potato (*Dioscorea batatas*), resembles the—to us—more familiar tuber in both

the above respects, although differing in botanical origin.

In the prepared starches the deficiencies alluded to are still more pronounced, so that they can only be used in conjunction with nutritious foods like milk and eggs. The following are examples :—

Arrowroot, a starch from the rhizome of *Maranta arundinacea,* much grown in the Tropics, e.g., Jamaica, Bermuda, Ceylon, etc., etc.

Conophallus flour, consumed in Japan, is obtained from an Aroid (*Amorphophallus*), the tubercles of which grow to a great size—4 to 6 lb. in weight.

The Apé starch of Tahiti is also from an Arum (*A. macrorhizomum*).

Portland sago (so called), formerly prepared in this country, was obtained from the common cuckoo-pint, another Arum (*A. maculatum*).

Tavolo, consumed in Madagascar in the form of 'dampers,' is derived from a kind of yam—*Tacca pinnatifolia.*

Tapioca and *manioc starch* are obtained from the manioc plant (*Manihot utilissima*), abundant in South America, and found also in parts of Asia and Africa.

Mapé starch, unlike the preceding, is the product of a fruit (*Inocarpus edulis*). It is consumed in Tahiti.

Palm starches.—Several members of the palm family supply starchy products :—

Sago from *Sagus Rumphii.*

Caryot starch from the Caryota palm.

Talipot starch from *Corypha umbraculata.*

Satranabe meal is the dried pith of the satranabe palm. It is eaten by the natives of Ambogo, and is the least to be recommended of these preparations,

for, according to Gallerand (*Comptes Rendus de l'Acad. des Sc.*, 1904), the proportion of indigestible cellulose is nearly 13 per cent.

Banana flour.—The banana in the unripe state is rich in starch, and when dried furnishes a meal, whereas in the ripened fruit (see under 'Fruits') the starch is practically completely converted into sugar. Banana flour is much poorer than wheat flour in protein.

Bread-fruit flour, from the bread-fruit tree (*Artocarpus incisa*), has a composition very similar to that of banana meal. It is largely used in the Moluccas.

Starchy nuts.—The *chestnut,* from *Castanea vesca,* and the *water nut,* from *Trapa natans,* are somewhat exceptional among nuts in being starchy and not oily; they have therefore been placed in this section. Chestnuts, which are highly indigestible when eaten raw, may be readily assimilated if properly cooked (boiled, steamed or roasted), and in that form constitute an important article of food in parts of Italy and Spain.

Composition of prepared starches. — Commercial starches prepared from wheat, maize and potato, also arrowroot, tapioca and tavolo starch, have the following range of composition, all being very much alike :—

Water	10 to 15 per cent.
Starch	78 ,, 89 ,, ,,
Fat	traces
Fibre	,,
Protein	0·2 to 1½ per cent.
Mineral salts . . .	0·2 ,, 1½ ,, ,,

Sago, apé and talipot starches, bread-fruit flour and conophallus meal are not so well freed from cellulose as are the above; they may contain as much as 4 per

cent. of fibre, which lowers their digestibility. A little more of the original protein also is found in them, viz., from 1 to 3½ per cent. in sago, and percentages ranging to 5 in talipot starch ; at the best, however, the amount of nitrogenous nutrients in these foods is but small.

Composition of natural starchy roots, nuts, etc. :—

	Water.	Protein.	Fibre.	Starch.	Mineral salts.
Undried					
Potatoes	70 to 80	1 to 3	0·4 to 1½	17 to 24	0·4 to 1·5
Yams	65 ,, 85	1 ,, 5	0·3 ,, 3	12 ,, 30	0·5 ,, 3
Chestnuts	50 ,, 60	2 ,, 4	0·7 ,, 1½	30 ,, 40	0·5 ,, 1¼
Water nuts	37 ,, 40	8 ,, 10	—	48 ,, 50	1¼ ,, 1½
Dried					
Potatoes	8 ,, 15	3 ,, 6	—	70 ,, 80	4 nearly
Unripe banana meal	9 ,, 14	3 ,, 5	2 to 3	75 ,, 83	2 to 3
Satranabe palm pith	8 ,, 14	8 ,, 12	8 ,, 13	60 ,, 70	6 ,, 8

CHAPTER XIII

OILY SEEDS, NUTS, ETC.

In the oily seeds, nuts, etc. (only those eaten by the human race are referred to here) there are both large amounts of fat and, as a rule, high percentages of protein, so that, in respect to fuel value as well as richness in building material, nuts might stand very high in the scale of foods; unfortunately, however, the cellulose or fibre in which these nutrients are enclosed, and their dense and hard texture, render digestion most difficult, and notwithstanding the glowing descriptions which certain food 'reformers' bestow upon them, the majority of persons in our time are compelled to exclude them from their dietaries.

The age when nuts could take an important part in the nutrition of man is past—long past.

In the selection of our food we cannot be guided by centesimal parts alone; assimilability must be considered also.

However, nuts need not be dismissed altogether; given a good digestion and the patience to chew pertinaciously they may provide variety, and when taken in very small quantities may be harmless.

Almonds.—Only the sweet almond (*Amygdalus communis*, var. *dulcis*) can be safely used as a food, as the bitter variety (*A. communis*, var. *amara*) yields prussic acid on moistening with water or saliva; but

the latter variety provides the agreeably-flavoured essence used in puddings and confectionery.

Walnuts, hickory and peccan nuts are all derived from one botanical family: the walnut from *Juglans regia*, the hickory from *Carya alba*, and the peccan nut from *Carya olivæformis*; the last two are well known in the United States.

Hazel, filbert, cob and Barcelona nuts are the produce of varieties of the hazel (*Corylus Avellana*). They have been used from the most ancient times.

The Brazil nut comes from the magnificent Para forest tree *Bertholletia excelsa*, which grows to a height of 100 feet. The nuts are enclosed in an outer shell of great hardness, about the size of a cocoa-nut. The Brazil nut has a pleasing flavour when fresh, and is rich in oil.

The earth nut, very widely cultivated in America, Asia and Africa, is the same as the American '*pea-nut,*' and is derived from *Arachis hypogæa.*

Beech nuts, from *Fagus sylvatica*, one of our best-known forest trees, are but little used as a food, although they compare fairly well with other nuts in composition.

Pine seeds, which are eaten in Tunis (according to Balland), contain an excessive proportion of cellulose, and should therefore be regarded with suspicion.

Pinoli, another pine product, imported from Italy, does not appear to be possessed of that drawback. The seeds contain some 40 per cent. of fat, and are used in confectionery.

Cocoa-nuts are the seeds of the cocoa-nut palm (*Cocos nucifera*).

Chestnuts, being starchy, appear in another section.

Composition of Oily Seeds, Nuts, etc.

	Water.	Protein.	Fat.	Fibre.	Other non-nitrogenous matters.	Mineral salts.
Almonds, fresh .	20 to 30	15 to 20	30 to 45	2 to 3	6 to 12	1½ to 2
,, dry .	4 ,, 8	20 ,, 25	50 ,, 55	3 ,, 8	7 ,, 14	1½ ,, 2½
Barcelona nut .	4 ,, 6	10 ,, 20	50 ,, 65	3 ,, 5	5 ,, 12	2 ,, 3
Filbert, dry . .	4 ,, 10	10 ,, 20	55 ,, 65	3 ,, 5	5 ,, 12	2 ,, 3
Brazil nut . .	4 ,, 8	10 ,, 20	50 ,, 65	2 ,, 5	2 ,, 4	3 ,, 4
Walnut, fresh .	16 ,, 28	10 ,, 15	35 ,, 45	1½ ,, 3	15 ,, 20	1½ ,, 2½
,, dry . .	4 ,, 8	15 ,, 20	50 ,, 65	3 ,, 8	16 ,, 22	2 ,, 2½
Hickory nut, dry .	2 ,, 5	15 ,, 25	55 ,, 65	3 ,, 5	—	2 ,, 2½
Peccan nut, dry .	2 ,, 5	10 ,, 15	60 ,, 75	2 ,, 4	—	—
Earth nut (pea-nut), dry . .	4 ,, 8	20 ,, 30	40 ,, 50	2 ,, 6	5 to 20	2 to 4
Beech nut . .	5 ,, 10	20 ,, 30	20 ,, 40	3 ,, 8	—	3 ,, 4
Cocoa-nut kernel, fresh . .	40 ,, 50	4 ,, 6	30 ,, 36	2 ,, 4	—	1 ,, 1½

CHAPTER XIV

FRESH ROOTS—MOSTLY NON-STARCHY

WHAT is said under fresh fruits and green vegetables in regard to low nutritive value holds good in great measure for the non-starchy roots, etc., with which we are here dealing, but the beneficial action of their salts is perhaps less strongly marked than is the case with those of fruits.

Their principal components are gum-like substances of the pectin class, together with sugar and fibre; the proportion of nitrogenous matters (protein, etc.) is rarely more than 2 per cent.

The onion (*Allium cepa*)—not really a root but a bulb—is probably the most easily digested of any of the food-stuffs in this group, on account of the soft character and low percentage of its cellulose; it contains sulphur in a labile (easily attackable) form, and has a wide-spread reputation for wholesomeness.

The leek (*Allium porrum*) is akin to the onion both chemically and botanically. Another botanical relative of the onion, **garlic** (*Allium sativum*), cannot be called a food, although containing three times as much solid nutriment as the former; its overpowering odour prevents its use except in homœopathic doses.

The carrot (*Daucus carota*) and **parsnip** (*Pastinaca sativa*), both of the *Umbelliferæ*, a botanical order from which we draw a number of edible vegetables and aromatic herbs (for instance, celery, parsley, fennel, etc.), yield some sugar and other carbohydrates, a very little protein, but a comparatively liberal quantity of salts—one or two per cent. on the average. When properly cooked they are well supported by the stomach if not consigned to it in unmasticated pieces of too large a size.

It is not possible to say a great deal in favour of the **turnip** (*Brassica rapa*) or its ally the **swede** ; the former is one of the most watery of the class which we are dealing with, and because of its fibrous texture often leads to flatulence ; nevertheless, its flavour is agreeable, and it supplies salts. The swede, generally regarded as only fit for cattle, is deserving of occasional patronage, for if sufficiently boiled (at least 4 hours, perhaps more) it affords a succulent dish of distinctive and by no means displeasing flavour.

The Jerusalem artichoke (*Helianthus tuberosus*), of the sunflower family (the first name is a corruption of 'girasole'), is akin to the potato so far as appearance and composition go, but it is less nutritive and usually has an earthy savour.

Salsifi, or salsafy (*Tragopogon porrifolius*), and **scorzonera**, or black salsifi (*Scorzonera hispanica*), are both deserving of wider recognition in this country as they are digestible and among the most nutritious of the root vegetables.

General Range of Composition of Non-Starchy Roots

(or roots for the most part non-starchy)

	Water.	Protein.	Sugar, etc.	Fibre.	Pectin, etc.	Mineral salts.
Carrot	80 to 90	0·5 to 2	1 to 4	0·8 to 3	0·8 to 5	0·7 to 2
Turnip	86 ,, 94	0·5 ,, 2	2 ,, 3	0·8 ,, 2	2 ,, 7	0·5 ,, $1\frac{1}{4}$
Swede	83 ,, 94	0·5 ,, $2\frac{1}{2}$	—	0·8 ,, $2\frac{1}{4}$	6 ,, 10 including sugar	0·5 ,, 2
Parsnip	80 ,, 90	0·8 ,, 3	—	0·8 ,, $2\frac{1}{2}$	ditto	0·6 ,, 2
Red beet	86 ,, 94	$1\frac{1}{4}$,, 3	total carbohydrates		5 to 10	0·4 ,, $1\frac{1}{2}$
Sugar beet	75 ,, 85	0·5 ,, 2	4 to 16	0·7 to $1\frac{3}{4}$	3 to 6	0·4 ,, $1\frac{3}{4}$
Jerusalem artichoke	72 ,, 82	1 ,, 3	—	0·7 ,, 2	12 ,, 18 with sugar	0·7 ,, $2\frac{1}{4}$
Onion	82 ,, 92	0·8 ,, 2	$1\frac{1}{2}$ to 3	0·8 ,, 1	4 to 8	0·4 ,, 1
Shallot (average)[1]	81	$1\frac{1}{4}$	$1\frac{3}{4}$	0·7	15	0·4
Salsifi[1]	81	4	0·7	2	$9\frac{1}{2}$	0·7
Scorzonera[1]	84	$4\frac{1}{2}$	2	2	$6\frac{1}{4}$	0·7
Garlic[1]	58	$6\frac{1}{2}$	traces	$1\frac{1}{4}$	32	$1\frac{1}{2}$

[1] Balland.

CHAPTER XV

FRUITS, GREEN VEGETABLES, MUSHROOMS, ETC.

Fresh fruits and green vegetables are not eaten so much for the nourishment they provide as for the health-giving properties, the organic salts of potash, lime and soda they contain, their agreeable flavours and their refreshing characters.

How little they contribute to tissue-building may be judged by the fact that about half a hundredweight of apples would be needed to replace the protein of one pound of beefsteak. But two or three apples will generally supply a sufficiency of alkaline base (after the organic acids have been oxidised away by metabolic processes) to correct the residual acidity arising from such cereal food as is ordinarily consumed in a day.

In the cooking of green vegetables half of their soluble salts are lost in the water that is thrown away, and of their nutrients much is unavailable through the inability of the human digestive ferments to penetrate the fibrous cells in which these nutrients are contained; nevertheless, the salts which are retained serve a useful purpose, and the open texture of the vegetable tissues is supposed to provide 'ballast' for, and exert a cleansing action upon, the intestines.

For these reasons fruits and vegetables should figure regularly upon the menu, and the habit of eating

fruits in particular should be cultivated. Natural tastes and idiosyncrasies must be consulted, for certain of these foods are digested readily by some persons but not by others.

Here we again urge the necessity for careful mastication. It so often happens that a soft and relatively nutritious fruit like the banana causes serious gastric trouble—particularly with delicate children—simply because, being soft, it is swallowed in large pieces unchewed.

Use of uncooked foods.—Uncooked fruits and vegetables contain digestive ferments (enzymes) which may possibly act as auxiliaries to those naturally occurring in the human system. Such enzymes are destroyed in cooking, hence the desirability of not relying solely upon cooked foods.

To avoid contaminations from the soil all uncooked vegetable foods must be very thoroughly washed, preferably under a stream of pure tap water.

Composition of fruits.—Notwithstanding the great diversity of flavour and appearance between the various fruits which we are accustomed to find upon our tables, there is a close resemblance in chemical composition between them. All are poor in protein, most of them exceedingly so. All contain sugars (saccharose or cane sugar, dextrose and lævulose) in increasing amount as ripeness proceeds, and free organic acids together with acid salts of potash, soda and lime are almost invariably present.

The predominant acids (there are generally more than one) are as follows :—

Malic acid in apples, pears and plums.

Tartaric and malic acids in grapes.

Malic and citric acids in currants and strawberries.

Citric acid in lemons, tomatoes, etc.

Acetic, citric and tartaric acids in pineapples.

Glyoxylic and a little benzoic acid in cranberries, bilberries and whortleberries.

The aromas are derived from volatile ethers or what are known chemically as esters; for example, ethyl butyrate in the pineapple, ethyl pelargonate in the quince, amyl acetate in the jargonelle pear, amyl valerate in the apple, and so on. (These compounds are now made artificially and used for imitation fruit syrups.)

GENERAL RANGE OF COMPOSITION OF FRUITS

	Water.	Protein.	Sugar.
Apple	80 to 88	0·2 to 0·5	5 to 12
Pear	80 ,, 88	0·2 ,, 0·5	6 ,, 14
Quince [1]	72	1	6½
Medlar	70 to 75	0·3 to 0·6	6 ,, 12
Grape	75 ,, 85	0·5 ,, 0·8	8 ,, 22
Plum	75 ,, 85	0·7 ,, 1·5	5 ,, 10
Damson	80 ,, 85	0·7 ,, 1·5	3 ,, 8
Greengage	76 ,, 84	0·3 ,, 0·8	3 ,, 12
Mirabelle	80 ,, 85	0·7 ,, 1·5	6 ,, 12
Cherry	75 ,, 85	0·8 ,, 2·5	4 ,, 12
Peach	80 ,, 85	0·6 ,, 1·2	4 ,, 8
Apricot	80 ,, 85	0·6 ,, 1·2	4 ,, 9
Strawberry	82 ,, 92	0·5 ,, 1·3	3 ,, 8
Currant, red, white or black	80 ,, 92	0·4 ,, 1·5	3 ,, 12
Gooseberry, ripe	82 ,, 88	0·6 ,, 1·5	4 ,, 8
Raspberry	80 ,, 88	0·6 ,, 1·5	4 ,, 8
Blackberry	82 ,, 88	0·5 ,, 1·5	3 ,, 6
Bilberry	78 ,, 82	0·4 ,, 0·8	3 ,, 6
Whortleberry	84 ,, 89	0·2 ,, 0·4	1 ,, 2
Mulberry [2]	85	0·4	9
Fig, fresh	76 to 86	0·8 to 2	12 to 18

[1] Balland (percentages rounded).
[2] Koenig ,, ,,

	Water.	Protein.	Sugar.
Orange . . .	78 to 88	0·8 to 1·5	1 to 7
Lemon . . .	78 „ 88	0·6 „ 1·3	0·5 (average)
Pineapple . .	81 „ 89	0·2 „ 0·6	8 to 15
Banana . .	66 „ 80	1 „ 2·5	15 „ 22
Melon . . .	90 „ 95	0·5 „ 1	1 „ 4
Pumpkin . .	83 „ 95	0·3 „ 1	1 „ 3
Cucumber . .	92 „ 97	0·4 „ 1·3	1 „ 3
Tomato . . .	92 „ 96	0·8 „ 1·3	2 „ 4
Pomegranate . .	75 „ 85	1 „ 1·5	5 „ 12
Egg plant (Servian)[1]	92	1·5	4 (with pectin, etc.)

To this table we have to add pectin and gum-like bodies, generally ranging from 1 to 3 per cent., but rather more in quince, medlar, melon and pumpkin; fibre and cellulose about 0·5 to 2 per cent. in the generality of fruits, but larger amounts in quince, medlar, blackberry, bilberry and pomegranate. Free acid 0·3 to 0·8 per cent. on the average, but very high in the lemon, which commonly contains 6 to 8 per cent. Mineral salts 0·3 to 0·8 per cent.; in the banana the range is from 0·7 to 2·25. The chief mineral constituents (see also remarks already made) are as follows, the figures here given being percentages of the ash of the fruit, not percentages of the fruit itself:—

Potash: 40 to 60.

Soda: Very much more variable than the potash and always much smaller in amount; 2·5 to 5 per cent. is the general proportion, but 10 per cent. has been found in the ash of the apricot and 25 per cent. in that of the apple.

Lime: 3 to 12; highest in oranges and lemons, viz., 20 to 30.

Magnesia: 3 to 8.

[1] Zega (percentages rounded).

Iron oxide: About 1 as a rule; most in strawberries, gooseberries and figs, 2 to 2·75.
Phosphoric acid: 10 to 15; most in grapes (say 20).
Sulphur, chlorine and silica: small percentages of the ash.

Composition of Dried Fruits

	Water.	Protein.	Sugar and other carbohydrates.
Apples	25 to 35	1 to 2	35 to 45
Pears	25 „ 35	1½ „ 2½	25 „ 35
Plums	25 „ 40	2 „ 4	30 „ 45
Apricots	25 „ 35	2 „ 3	—
Raisins	15 „ 30	2 „ 3	50 to 75
Currants (Grocers')	20 „ 30	0·5 „ 2	50 „ 65
Dates	15 „ 25	2 „ 3	40 „ 55
Figs	25 „ 35	2 „ 4	30 „ 60
Banana, ripe, dried	20 „ 30	3 „ 6	50 „ 70
Locust (St. John's bread)	15 „ 25	4 „ 6	30 „ 40
Netté meal [1]	5 „ 10	3½ „ 4½	30 „ 45
Narras [2]	13	9½	18½

Average Range of Composition of Green Vegetables

	Water.	Protein.	Pectin, sugar, etc.
Peas and beans—*see special list.*			
Asparagus tops	90 to 94	0·7 to 2	2 to 7
Cauliflower	88 „ 92	2 „ 3	3 „ 5
Cabbages (various)	88 „ 94	1 „ 3	3 „ 8
Brussels sprouts	83 „ 87	2½ „ 4½	5 „ 8
Spinach	86 „ 92	2½ „ 4	2 „ 5
Endive	92 „ 95	1 „ 2	2 „ 4

[1] Netté meal is prepared from the pods of *Parkia biglobosa* of the *leguminosæ* and is used as a food in Central Africa; in addition to sugar it contains 20 to 40 per cent. of starch.

[2] Narras, which is consumed in German S.W. Africa, is obtained from the fruit of *Acanthosicyus horrida*, one of the *curcurbitaceæ* or cucumber family. The dried fruit contains some fat, much fibre, and an inordinate amount of mineral matter. The above analysis is by Balland.

	Water.	Protein.	Pectin, sugar, etc.
Lettuce . .	92 to 96	0·8 to 2	1 to 3
Celery . . .	85 ,, 93	1½ ,, 2	4 ,, 10
Kohlrabi . .	80 ,, 90	1½ ,, 5	4 ,, 12
Watercress . .	85 ,, 93	1½ ,, 2½	2 ,, 4
Parsley . .	80 ,, 88	2 ,, 4	6 ,, 10
Artichoke, French (lower portion)[1] .	81	3¾	12¾ (average)

Sauerkraut, a form of preserved salted cabbage, very popular in Germany, has the following composition, according to E. Feder (*Zeit. Untersuch. Nahrung., etc.*, Sept., 1911): Water 88 to 91, nitrogenous compounds (protein, etc.) 1·3 to 1·7, fat 0·3 to 0·4, lactic acid 1¼ to 1¾, sugar nil to 1·3, mannite, a carbohydrate akin to a sugar, 0·8 to 1, cellulose 0·9 to 1, ash 1·4 to 4, common salt 0·8 to 3·3 per cent.

MUSHROOMS, ALGÆ, ETC.

Of the immense number of non-flowering plants, known botanically as the *Cryptogamia*, but a small number have been used for food, the following being among the best known :—

Iceland moss (*Cetraria islandica*), a lichen which contains mucilaginous matters, lichen starch and inulin. After being freed from its bitter principle by extraction with weak alkali, it is occasionally employed as a mild tonic food in cases of catarrh, etc.

Mushrooms.—In consequence of so many varieties being poisonous very careful discrimination is necessary, the following differences between the edible and the non-edible species (due to Bentley) being helpful in this connection :—

[1] Balland.

Edible Mushrooms	Poisonous Mushrooms
Grow solitary in dry, airy positions.	Grow in clusters in woods and dark, damp places.
Generally white or brownish.	Usually with bright colours.
Have a compact, brittle flesh.	Flesh tough, soft and watery.
Do not change colour by the action of the air when cut.	Acquire a brown, green or blue tint when cut and exposed to the air.
Juice watery.	Juice often milky.
Odour agreeable.	Odour commonly powerful and disagreeable.
Taste not bitter, acid, salt or astringent.	Have an acid, astringent, acrid, salt or bitter taste.

'All fungi should be avoided also which insects will not touch, and those which have scales or spots on their surface; and, whatever may be their apparent properties, all those which have arrived at their full maturity, or which exhibit any sign of change, should be used with caution.

'In cases of doubt, macerate the mushrooms, cut in slices, in vinegar and water for about an hour, then wash them in boiling water before being cooked. It has been proved that many injurious fungi lose their poisonous properties when thus treated. It is quite true that by following the above rules strictly edible species will occasionally be thrown aside, but this is of little consequence comparatively, as by doing so all injurious ones will certainly be rejected. Thus all highly coloured fungi are not poisonous; for instance, *Agaricus cæsareus* is, according to Berkley, at once the most splendid and the best of the esculent fungi.'

Soil and climate affect the properties of mushrooms a great deal, so that species which are eaten in one country may be poisonous in another. Thus 'even

the common mushroom is sometimes poisonous, and in Italy and Hungary is generally avoided.'

It is usually stated that the fungi contain much nitrogen—even Bentley made that assertion; but in reality the proportion of protein and other nitrogenous substances is quite small, and of this about two-thirds is non-assimilable, the real nutritive protein being only one or two per cent.

More correctly might one say that the proportion of protein to other nutrients is large, but this does not alter the fact that the total amount of nutritive matter in the fungi is small. They are flavourings rather than foods.

The composition of the principal edible fungi, the common mushroom, *Agaricus campestris*, and other varieties, as well as of the truffle (*Tuber cibarium*) are given in the next table:—

COMPOSITION OF EDIBLE FUNGI

	Water.	Protein and other nitrogenous matters.	Non-nitrogenous matters.	Fibre.	Ash.
Agaricus esculentus	93·7	1·7	3·3	0·4	0·8[1]
Agaricus arvensis	89·5	6·7	2·1	0·8	0·7[1]
Lactarius piperatus	85·7	6·4	2·5	3·3	1·0[1]
Coprinus comatus	94·3	2·0	2·9	0·2	0·5[1]
Truffles	72 to 78	8 to 10	4 to 10	5 to 9	$1\frac{1}{2}$ to $2\frac{3}{4}$
Morel (Morella esculenta)	86 „ 94	3 „ 6	2 „ 5	0·8 „ 1	—
Boletus edulis	85 „ 90	3 „ 7	3 „ 6	0·8 „ 1·2	—

[1] Analyses by A. Zega, *Chem. Zt.*, 1902, 10.

Algæ.—Several species are used for food; they are noted for their gelatinous, demulcent properties, e.g.:—

Carrageen or *Irish moss* (*Chondrus crispus*), useful in the making of jellies.

Gelidium corneum, largely used in Japan. It yields the gum-like substance *gelose*, which has extraordinary gelatinising powers.

From the genus *Gracillaria* is obtained *Agar-agar*, another material used to make jellies.

Nostoc phylloderma, a fresh-water alga, and also many sea-water algæ are important articles of commerce in Japan, yielding the so-called *Japanese isinglass*, edible jellies, etc. The plants, after cleaning, are cut up and dried in sheets. The composition of this product has been found to be as follows (*Jnl. Chem. Soc.*, 1906, ii. 884): Water 18, crude protein 24·7, crude fibre 3·6, gums (pentosans, galactan, etc.) 6·4, ash 13·3, other matters (chiefly starches) 58·4.

Over £400,000's worth of seaweed products were sold in Japan in 1904.

Kombu (*kelp*), which has various culinary uses, is prepared from *Arthrothamnus bifidus* and several species of *laminaria*, and has the following composition (according to K. Oshima):—

Composition of Edible Fungi

Water	22·8	to	24·4
Protein	4·0	,,	6·7
Fat	0·7	,,	1·7
Soluble non-nitrogenous matters	31·9	,,	47·0
Crude fibre	6·0	,,	10·2
Ash	17·2	,,	27·3

The proportions of mineral matters and fibre are, it will be observed, extraordinarily high.

CHAPTER XVI

SUGARS, JAMS, CONFECTIONERY, ETC.

Except for comparatively small quantities of sugar obtained from the maple and one or two other sources, the table sugar used in this and most other countries in modern times was, until a few decades ago, nearly wholly derived from the sugar cane (*Saccharum officinarum*), but the beet-sugar industry has developed with such enormous strides that the older colonial product is fast giving place to its younger rival, beet sugar, with which it is chemically identical.

In 1910 the world's beet and cane-sugar production was :—

8,660,463	tons	cane	sugar, and
6,606,781	,,	beet	,,

The chief cane-sugar producing countries are :—

British India .	2,125,300	tons	raw sugar	(in 1910)
Cuba . .	1,804,349	,,	,,	,,
Dutch East Indies	1,200,618	,,	,,	,,

the balance being distributed between various West Indian Colonies, the United States, South America, etc.

Beet sugar is manufactured principally in :—

Germany . .	2,004,653	tons	raw sugar	(1910)
Russia . . .	1,255,345	,,	,,	,,
Austria-Hungary .	1,225,589	,,	,,	,,
France . . .	802,341	,,	,,	,,
United States . .	457,562	,,	,,	,,

Belgium . .		244,411 tons raw sugar (1910)
Holland . . .		191,691 ,, ,, ,,
Sweden . . .		124,959 ,, ,, ,,
Italy . . .		109,014 ,, ,, ,,
Other European countries . .	under	200,000 ,, ,, ,,

Consumption of sugar per head of population.—Apart from Australia, which disposes of 123·3 lb. per head annually, the United Kingdom and the United States are the largest sugar eaters, then follow Canada and Germany, thus :—

	1909. lb.	1910. lb.
Australian Commonwealth . .	122·31	figs. not available
United Kingdom, raw and refined sugar	85·77	82·43
United States, mostly raw sugar .	80·43	79·90
Canada	66·46	figs. not available
Germany	38·75	38·61
Holland	37·43	37·25
France	33·92	34·13
Belgium	28·33	29·12
Austria-Hungary	22·88	24·09

Etc., etc.

Composition of sugar.—Both cane and beet sugar are one and the same chemical substance—saccharose, $C_{12}H_{22}O_{11}$, and the degree of refinement to which it is brought commercially is remarkable, ordinary white sugar usually containing from 99·7 to 99·9 per cent. of pure sugar, with very small traces of moisture, mineral matters, etc.

Properties of sugar.—From the dietetic point of view, sugar is a calefacient food, heat-giving but not tissue-forming, i.e., acting solely as a fuel. It is one

of the most rapidly absorbed of all nutrients, and may be taken in comparatively large quantities by most persons without injury being immediately discernible. But there are serious and well-known objections to too liberal indulgence in sugar, such as its indirectly destructive action upon the teeth and injurious effect upon the appetite, which with other consequences are so noticeable in children who partake too freely of sweetstuffs. By replacing fats with sugar to any large extent the general health may be seriously affected.

Part at least of the ill-effects of too much sugar is believed to be due to its nearly complete freedom from mineral salts—especially iron compounds.

Its very purity is a defect.

Molasses or treacle, by-products of sugar manufacture, frequently contain, on the other hand, an excessive amount of lime salts (treacle often yields 10 per cent. or more mineral ash) and much organic matter that is not saccharose.

Honey, the sugary fluid collected by bees from flowers, the sweetening agent used by the ancients and from which nectar, 'the drink of the gods,' was prepared, may be described as a syrup of invert sugar, for it contains very little uninverted saccharose unless fresh (unripe); the other components of honey are water, wax, traces of flavourings of floral origin, etc.

As a food it has the same value as the sugar it contains—usually about 75 per cent.

Witte, who has made a special study of honey (*Zeit. Untersuch. Nahrung., etc.*, 1909 and 1911), found the

range of composition of genuine samples to be as follows (figures are slightly rounded) :—

Composition of genuine honeys :—

	per cent.	
Water . . .	14 to 20	average about 17
Invert sugar . .	68 „ 77	total sugar, average about 75
Saccharose . . .	trace „ 7	
Substances other than sugar . . .	3 „ 15	
Acidity (formic acid) .	0·06 „ 0·15	
Nitrogenous substances (about ½ is protein) .	0·25 „ 0·5	
Mineral salts (ash) .	0·06 „ 0·35	

Adulteration and impurities of honey.—Honey is very largely adulterated with glucose or starch syrup, a form of sophistication not so easy of detection as might be supposed, because the artificial and the natural sugars closely resemble each other. Genuine honey is frequently charged with micro-organisms—bacteria and mould spores in great variety, and occasionally some of a harmful character are included among them. This fact suggests the propriety of sterilising honey before consumption.

Jams.—In the manufacture of jams fruit and sugar (or syrup) are boiled together until a certain consistency is attained. A hot juice ready to gelatinise on cooling has, according to Goldthwaite (*J. Ind. Eng. Chem.*, 1909), a boiling point of about 103° C. (217½° F.) and a specific gravity of 1·280.

Pectin, the natural gum-like substance of fruits, and also a certain acidity are essential to the production of jellies of good texture. During the boiling much of the added saccharose (cane or beet sugar) becomes

changed to invert sugar or glucose, and the greater part of the volatile essential oils of the fruit are lost.

Properties of jams.—Their easy digestibility is their chief virtue, but, like nearly all sugary foods, jams are poor in mineral constituents and protein.

Composition of jams.—Most fruits when manufactured into jam by the ordinary methods yield products which in their broad general characteristics are remarkably alike; so that whether made from raspberries, currants, plums, apples, apricots, peaches, cherries, gooseberries or oranges the proportion of the principal constituents will be found to lie within the following ranges (with perhaps some exceptions of but little import) :—

	per cent.	
Water	18 to 40	
Invert sugar . . .	12 ,, 50	
Saccharose (cane or beet sugar) . . .	nil ,, 40	
Protein . . .	0·3 ,, 0·8	
Pectin, etc. . . .	1 ,, 7	
Insoluble matters (stone excluded) . . .	1 ,, 10	(usually under 5)
Mineral salts (ash) . .	0·3 ,, 0·9	(,, ,, 0·5)

Adulteration of jams.—The substitution of a cheaper for a more expensive fruit is by no means uncommon; apple pulp, for instance, is very widely employed in many kinds of jam, avowedly with the object of giving body, but no doubt also to lower cost. Agar-agar and other gelatinising materials are occasionally met with, and artificial colouring is not unknown, nor is the substitution of glucose for ordinary sugar. Of course the best firms do not resort to these practices.

Confectionery in general (including pastry). As there is such an immense variety of preparations embraced within this term it will not be possible to give more than a very brief survey of the chief kinds, and for that purpose a selection will be made from the interesting classification to be found in the Austrian 'Codex alimentarius' (*vide* Koenig's 'Nahrungs- und Genussmittel').

Group I

Confectionery which, in addition to sugar, contains other foods such as flour, eggs, butter, fruits, spices, etc.

(*a*) Baked pastries.

1. Made with yeast or baking powder, and containing butter, eggs, milk, sugar.
2. Without yeast or baking powder. The same ingredients as above, with perhaps spices or fruits.
3. Cakes and biscuits.—Flour, butter, sugar, eggs, spices, almonds, etc.
4. Butter cakes.—Flour and butter; sugar only for sprinkling.
5. Macaroons, almond cakes, etc.—Flour, sugar, white of egg, spices, etc.

   (Marzipan, which was included in this class, was found to contain about 10 per cent. of water, 28 to 32 per cent. of fat, and 28 to 44 of sugar.)
6. 'Patience' cakes.—Flour, sugar, white of egg, with or without spices.
7. 'Soufflets' or 'Baisers.'—White of egg and sugar.

8. Foam or cream pastries.—Flour, sugar, eggs, with or without spices. Used for enclosing cream or 'foam.'
9. Cakes and tarts.—Very various; among the ingredients are flour, butter, sugar, eggs, nuts, seeds, spices, fruits, alcoholic fluids. They are often coated with a glazing of sugar, with or without white of egg, sometimes perfumed; or the coating may be of chocolate.
10. Honey cakes.—The true German '*Lebkuchen*' should be made of flour and honey; frequently lemon peel is used and baking powder.

    Examples of this class yielded the following figures: Water 5 to 17, protein 4 to 7½, fat 0·6 to 5, invert sugar 12½ to 24, starch 32 to 46, ash 0·4 to 2 per cent. In other samples the total sugar reached 55 per cent.
11. Fruit cakes.—Chiefly made with sweet fruits, as figs, dates, currants, pears.

(*b*) Not baked.

Ices.—Milk or cream, sugar, spices, fruit juices, vanilla, coffee, etc.

Crêmes.—Sugar, white of egg, fruit juices, with or without cream.

Jellies.—Sugar, fruit juices, gelatin.

Group II

Mainly sugar; confectionery in the restricted sense.

1. Caramels.—Nearly wholly sugar, fused and flavoured, and generally containing a little glucose.

(In the manufacture of these, sugar with a little water is heated to a temperature of 113° C. (237° F.); an addition of 10 per cent. of glucose prevents crystallisation.)

Percentage composition: Water 3 to 10, saccharose 61 to 96, invert sugar trace to 30, other ingredients 0·3 to 4·5, ash a trace.

Gum drops.—Sugar two-thirds or more, gum arabic up to one-third.

2. Fondants.—Made like caramels but without heating the sugar to so high a temperature, so that the mass on cooling crystallises.
3. 'Conserve bon-bons' (often erroneously termed creams).—For the manufacture of these, powdered sugar is ground with a little syrup and flavouring, and subsequently let crystallise without any heating.

   These are 'sweets' pure and simple, the proportion of sugar reaching 99·7 in some samples.
4. Lozenges.—Similar in composition to the last.
5. Fruit lozenges.—Sugar, coloured or uncoloured, half solidified, is mixed with powdered sugar previously aromatised with fruit flavourings, essential oil, spirit (cognac, rum, punch, etc.) or the like, and subsequently poured on to a table and stamped out to the desired shape.
6. Pastilles.—Sugar, coloured or uncoloured, fused or unfused, flavoured and stamped in a press. After drying, may be glazed with gum or dextrin. A little starch is sometimes used to prevent sticking in the press.

   Peppermint drops made on these lines were found to contain less than 1 per cent.

of water, 96 per cent. of sugar, $3\frac{1}{2}$ per cent. of starch and gum tragacanth, and a trace of mineral ash.

7. Pralines.—Various sugar or chocolate-coated sweets.

   These differ from the preceding classes in containing fat (as much as 20 per cent. in some specimens) and a little proteid matter.

8. Dragées.—Composed of an interior sugary mass or a fruit, nut or seed (e.g., almond or coriander), and an outer sugar coating consisting of sugar, starch and gum.

Group III

Candied fruits or other candied vegetable products, with an outer transparent sugar glazing.

A sample of candied orange peel contained 15 per cent. of water, 79 per cent. of sugar, $1\frac{1}{4}$ per cent. of fibre and 0·36 per cent. of mineral salts.

Adulteration of confectionery.—Mineral powders have been used for dusting instead of sugar. Starch, when present in more than small proportions in sweet-stuffs must be regarded as an adulterant; occasionally, too, poisonous flavourings have been unintentionally used—for example, prussic acid may be introduced from essence of almonds, and nitro-benzol, which has a strong almond-like odour but is very toxic, may have been substituted for the natural essence.

Artificial sweeteners.—Saccharin, a coal-tar product having 500 times the sweetening power of sugar, must not be regarded as a food but merely as a flavouring. Not being fermentable, it has been employed in the

manufacture of mineral waters and other non-alcoholic beverages. It is also used by persons troubled by diabetes.

Dulcin is a similar substance.

Artificial sugars—real sugars, if we except those derived from starch—exist at present only as laboratory curiosities.

CHAPTER XVII

DRINKS—CONDIMENTS

In an earlier chapter it was shown that vital processes are carried on in a dilute aqueous medium, that water is continually escaping via lungs, skin and kidneys, and must be replaced in order to maintain the normal degree of dilution of the body fluids, and that, further, no liquid but water is fitted for the duties involved.

To add to water any soluble substance of whatever kind is to lower its efficiency as a solvent and diluent.

But men of all races and at all times have demanded something more than water alone; stimulating and nutritive beverages have been sought for—and found.

Alcohol was undoubtedly an early discovery; it would readily form in a warm climate whenever fruit or fruit juices were allowed to stand for a day or two, since the necessary yeasts are generally to be found on the surfaces of fruits. At a very remote period the Indians were acquainted with alcohol and devised ingenious appliances for distilling it.

In other directions, too, discoveries of exhilarating infusions of leaves and berries were made, and it is interesting to note that from the vast number of plants whose properties our ancestors must have tested, those

which have been selected and most widely used by different peoples in the preparation of such beverages (apart from those of alcoholic nature) owe their action upon the nerves to one and the same substance—caffeine; or to its near relative—theobromine. In tea, coffee, kola nut, maté (Paraguay tea) and guarana the active principle is caffeine; that of cocoa (in which caffeine is also present, but in very small amount) is theobromine.

Another fact of interest is that these stimulant bases—caffeine and theobromine—are derivatives or close chemical allies of the xanthine (purine) compounds which give to soups or meat extracts their property of nerve stimulants.

Statistics.—The consumption of all alcoholic beverages—wines, spirits and beer—has been steadily declining in the United Kingdom for several years. From the figures given below (from the Board of Trade Returns) it will be seen that the United Kingdom is one of the principal beer-drinking countries, but by no means the largest when measured by head of population; it is a relatively small spirit-consuming nation, and the smallest of all the wine-consuming powers.

Britishers at home and abroad are the largest tea-drinkers among the white races, but the inhabitants of the Mother Country are by far the smallest coffee consumers.

Spirits.—In total consumption the United Kingdom stands sixth, and per head of population eleventh, among the great powers, thus:—

Consumption of spirits during 1909 *in gallons of proof spirit,*[1] *according to Board of Trade Returns* :—

	Per head.		Total.
Russia	1·10	..	202,524,000 gal.
Germany	1·58	..	164,054,000 ,,
United States of America .	1·14	..	116,530,000 ,,
France	1·32	..	93,536,000 ,,
Austria (without Hungary)	1·32	..	59,906,000 ,,
United Kingdom . .	0·70	..	46,592,000 ,,
Hungary	1·54	..	41,668,000 ,,
Italy	0·56	..	24,024,000 ,,
Netherlands . . .	1·34	..	13,684,000 ,,
Belgium	1·03	..	13,442,000 ,,

The Danes, with 2·16 per head, are the greatest spirit-drinkers.

Beer.—In total production the United Kingdom holds third place. Per head of population the relative position of this country is second if we take Germany as a whole, or fifth if the individual German states are separately considered.

	Total consumption in 1909.
United States . .	1,459,628,000 gal.
Germany . . .	1,418,714,000 ,,
United Kingdom . .	1,164,429,000 ,,

Consumption per head (1909) : Bavaria 50·6, Baden and Wurtemberg 32·1, Germany as a whole 22·0, Belgium 46·0, United Kingdom 26·2, Denmark 19·1, United States 16·5, Austria 14·3, Sweden 11·1, France 7·9, Norway 4·2 gallons.

Wines.—The United Kingdom, judged per head of

[1] Proof spirit contains 57 measures of real or absolute spirit in 100 measures.

population, occupies the fifteenth place, or eleventh in total consumption of wines.

Consumption of wines during 1909 *in gallons* :—

	Per head.		Total.	
France	32·8	..	1,283,678,000	gal.
Italy	26·0	..	842,776,000	,,
Spain	15·2	..	288,090,000	,,
Austria (without Hungary)	5·3	..	148,720,000	,,
Portugal	22·8	..	121,814,000	,,
Hungary	4·0	..	82,082,000	,,
Germany	0·97	..	62,128,000	,,
Switzerland (1908)	14·7	..	52,030,000	,,
United States	0·58	..	51,463,000	,,
Bulgaria	6·8	..	29,040,000	,,
Roumania	4·2	..	28,050,000	,,
United Kingdom	0·26	..	11,394,000	,,
Servia	3·1	..	8,712,000	,,
Belgium	1·01	..	7,590,000	,,
Netherlands	0·33	..	1,914,000	,,

Tea.—New Zealanders, among the white races, hold the record for tea-drinking, their consumption being 7·45 lb. of dry tea per head; then follow the Australians 6·83, the inhabitants of the British Isles 6·37, Canadians 4·43.

Neither the United States nor any Continental power comes anywhere near these figures, the largest consumers of tea outside the United Kingdom and Colonies being the Dutch 1·73, Russians 1·01 and United States 1·24 lb. per head (1909).

Coffee.—With regard to coffee the position is entirely different; thus, for the same year (1909) the consumption per head was :—

The Netherlands 16·10 lb., Belgium 12·43, United States 11·45, Germany 7·73, Cape of Good Hope 6·97,

France 6·05, Austria-Hungary 2·45, Canada 1·68, United Kingdom 0·67.

The total quantities of tea and coffee consumed in the United Kingdom in 1909 and 1910 were :—

	1909.	1910.
Tea . .	283,330,000 lb.	286,892,000 lb.
Coffee . .	29,667,000 ,,	29,195,000 ,,

Cocoa and chocolate.—As a large amount of cocoa is introduced into confectionery, we give the figures for the latter as well as those referring to cocoa and chocolate not entered as confectionery (from the 'Census of Production,' 1907).

	lb.
Cocoa or chocolate, ground, prepared or in any way manufactured (except chocolate confectionery)	59,024,000
Cocoa husks or shells	5,488,000
Cocoa butter	4,256,000
Sugar confectionery, including chocolate confectionery	440,048,000

Water.—Water having been already considered from various aspects—see in particular the chapters upon the human body, food constituents, metabolism, dietaries, and the opening remarks on drinks—it will not be necessary here to further emphasise its dietetic importance. A brief reference to the composition of ordinary drinking water should suffice.

Impurities in water.—Percolation through the soil necessarily involves a certain degree of contamination which it is the aim of the water companies to reduce to a minimum, an aim achieved in most cases with a tolerable but not complete success.

Of the mineral salts taken up by water from the earth the chief are carbonates and sulphates of lime

and magnesia, the carbonates being held in solution by free carbonic acid. Other substances present in smaller quantities are common salt, nitrates, silica, ammonia compounds and organic matters of various kinds, to which must be added living organisms (microscopic and otherwise). The most objectionable impurity, and one which is unfortunately quite common, is sewage contamination.

Lime and magnesia salts give to water the property of 'hardness,' and where they are found in water in more than very moderate proportions—say above 20 parts in 100,000 parts—the water should be 'softened' before use, this being most simply effected, when the hardness is due to carbonate, by boiling and allowing the water to settle. In this process some of the carbonic acid is expelled and the greater part of the carbonates precipitated.

Character of typical drinking waters.—(Quantities are in parts per 100,000.)

Upland surface waters: Impurities chiefly vegetable; total solids 2 to 10 as a rule; hardness low—say 1 to 5.

Surface water flowing from cultivated land: Less pure than the above; total solids 10 to 30; hardness 5 to 25.

Water from shallow wells: Should be used with great caution; composition very variable. Often dangerously polluted.

Water from deep wells: Less liable to organic contamination than the above. Sometimes very hard, in other cases quite soft.

London water supply: Total solids 25 to 40; hardness 15 to 25. Not entirely innocent of sewage

contamination. Taken fresh from the filter beds, bacterial population generally in the ratio of 5 to 10 per cubic centimetre (say 150 to 300 per ounce).

Rain water: Usually traces of organic matters, ammonia, nitrates, chlorine, etc.

Diseases spread by water.—Numerous instances of epidemics spread by water are on record; it is consequently most essential to boil all drinking water in regard to which there is the slightest suspicion, for in that way the danger can be removed most readily. Filtration through a Pasteur or a Chamberland filter is also usually sufficient to remove disease germs, provided the appliance be of standard quality and kept thoroughly clean.

A small quantity of lime in drinking water appears to be innocuous—it has even been said to be beneficial; but when overcharged with calcareous matter the water may be injurious to persons liable to stone or kindred ailments. In such cases as much as possible of the lime should be eliminated by boiling. Filtration unassisted by boiling will not remove carbonate of lime. Sulphate of lime (gypsum) cannot be extracted by either process, but may be thrown out by soda; to carry this out effectively, however, involves an analysis of the water and very careful manipulation not easily accomplished by the householder.

The only method of preparing absolutely pure water is that of distillation. Although this is a slow process, and not a cheap one, it is nevertheless occasionally resorted to where the ordinary water supply is objectionable, and if a gas supply is at hand distillation may be carried out without much trouble by using one of the automatic stills now available for domestic use.

Distilled water, however, is not to be generally recommended ; a *pure* spring water, i.e., one free from organic contamination, is much to be preferred.

Tea.—The dried leaves of *Thea sinensis* or one or other of the varieties *T. Bohea, T. Assamica, T. virida,* contain essential oil which gives to them their agreeable odour, caffeine, the stimulant to brain and nerve, and tannic acid, the astringent, besides various indifferent matters common to the vegetable kingdom.

Caffeine . . .	2 to nearly 5 per cent. (maximum)
Tannic acid (tannin)	7 ,, 15 per cent.
Mineral matters .	5 ,, 9 ,, ,,
Moisture . .	5 ,, 10 ,, ,,

Further : gums, pectin, cellulose, protein, sugar, etc.

About 35 to 40 per cent. is soluble in water.

Whereas formerly we drew our supplies of tea entirely from China, at present they are obtained in great part from India and Ceylon, very little coming from the original source ; thus :—

Quantities of tea entered for home consumption in 1910 :

	lb.
From British East Indies, excepting Ceylon	162,504,000
,, Ceylon	93,370,000
,, China	10,288,000
,, Other Countries	20,916,000

In addition to the countries named, Japan, Formosa and Java produce considerable quantities of tea ; Natal, too, is now entering the field.

Comparison of Indian and Ceylon with China teas.—By drawing our supplies from inter-imperial sources our economical gain may be great, but our dietetic interests are to some extent sacrificed thereby, for

Indian and Ceylon teas are on the average much richer in tannin than are those from China; and modern medical opinion is fairly unanimous in regarding tannin as prejudicial to digestion, as it forms with proteid matters leathery insoluble compounds that are acted upon by the digestive ferments much less easily than proteins that have not been 'tanned.'

For this reason tea should not be drunk with the more important meals of the day, when meat or other food rich in protein constitutes an essential part of the repast.

Tatlock and Thompson (*Analyst*, 1910, 10) found the percentage of tannin in the chief kinds of tea to be as follows:—

Indian teas . .	13·32 to 14·98,	average 14.33
Ceylon „ . .	10·13 „ 13·91	„ 12·29
China „ . .	7·27 „ 10·91	„ 9·50

In regard to caffeine, the differences are less striking, but the three teas stand in the same order:—

Indian teas . .	average 3·45
Ceylon „ . .	„ 3·25
China „ . .	„ 3·0

or say $3\frac{1}{2}$ per cent. in Indian, $3\frac{1}{4}$ per cent. in Ceylon and 3 per cent. in China teas.

The flavour of China tea is in general weaker but more delicate than that of Indian or Ceylon teas, being often very fragrant in the best qualities.

Effects of tea-drinking.—Much tea-drinking induces indigestion, nervousness and irritability; carried to excess, it may bring on complete nervous breakdown, such as that from which tea-tasters suffer.

As a nation, our consumption of tea is dangerously large.

Action of water and air upon tea.—The quality of the water used for 'making' tea has a great influence upon the flavour of the infusion; hard waters are in general to be preferred. Contact with the air is prejudicial and must be avoided as far as possible, the aroma being exceedingly sensitive. Tea must be drunk within 10 minutes of making, as not only is the aroma lost on standing, but too large a proportion of the tannin is extracted from the leaves.

Adulteration of tea.—The older writers on foods were accustomed to enumerate many gross forms of tea adulteration—facing with Prussian blue and the like—but these are things of the past, in this country at any rate. At the present day there appears to be but little serious sophistication of tea; there are some notable defects, however, to be occasionally met with. Thus, Dr. A. Besson of Basle draws attention to the large proportion of stalk present in some samples. His results were :—

China green tea . . .	0·4	to	5·3 %,	average	3·1
Foochow . . .	4·1	,,	17·5 ,,	,,	9·3
Hankow . . .	8·6	,,	17·1 ,,	,,	10·9
Java . . .	4·4	,,	29·9 ,,	,,	19·9
Indian . . .	11·5	,,	37·4 ,,	,,	24·0
Ceylon . . .	5·8	,,	43·4 ,,	,,	25·7

Bicarbonate of soda has been added to tea to darken the colour; such a practice should be strongly condemned.

Coffee.—The coffee plant (*Coffea arabica*) is grown largely in Brazil and Central America, these countries together providing us with two-thirds of our supplies of the seeds (popularly known as berries).

The United Kingdom retained for home consump-

tion in 1909 and 1910 the following imports of coffee :—

	1909. lb.	1910. lb.
From Brazil . . .	31,351,000	40,197,000
,, Central America (Costa Rica, Salvador, Honduras, Guatemala) .	32,308,000	36,780,000
,, British East Indies .	9,905,000	13,368,000
,, Columbia, Panama, Venezuela . .	7,718,000	5,831,000
,, Mexico, British W. Indies, Dutch E. Indies, etc. . .	6,008,000	4,091,000
Received indirectly through other countries . .	4,442,000	4,651,000

Composition: effect of roasting.—Roasted coffee 'berries' contain from one-third to half as much caffeine as is usually present in tea ; in the raw product the proportion is a little higher, the process entailing a loss of one-fifth of the stimulant base, besides one-tenth to one-fifth of the organic matter in general ; volatile aromatic oil also escapes, but the high temperature is inevitable, as only by its aid can the rich aroma be developed.

The special form of tannin existing in coffee differs from that of tea; Gorter found (*Annalen d. Chem.*, 1908) that it consists of two substances, which he names coffalic and chlorogenic acids—the latter designation being conferred because a bright green colour is developed when the acid comes in contact with iron chloride. Part of the caffeine is combined with this chlorogenic acid and the latter in turn with potash, the triple combination being termed potassium-caffeine-chlorogenate. These facts are only mentioned to show that the compounds in which caffeine exists

in tea and coffee are quite distinct, this partly accounting for the difference in action of the two beverages.

Other compounds of coffee.—Besides the substances named above, coffee contains sugar, fat, protein (in small quantities), gum-like bodies such as dextrin, galactan, mannan, etc., fibre (partly carbonised by the roasting) and mineral salts; of the latter, potash forms about two-thirds. The ash of coffee is peculiar in containing very little soda, silica or chlorine.

Properties.—From the lower proportion of caffeine, coffee would be expected to exert correspondingly less energetic action upon the nerves; in preparing the beverage, however, a larger weight of coffee than of tea is used per cup—twice the amount in the ordinary method of making breakfast coffee, and still more in *café noir*; secondly, other constituents of coffee, the empyreumatic substances produced by roasting, contribute to the general effect.

'Black coffee' (*café noir*), while possibly harmless when but one small cup is taken, may, when many times this quantity is consumed in a day, engender a deplorable neurotic condition. Excessive coffee-drinking is uncommon with us, but is by no means infrequent in other countries—Brazil, France and elsewhere.

In moderation, coffee by its action on the nerves tends to counteract the feeling of fatigue and the desire for sleep, increases the force of the pulse and stimulates both muscular and mental activity.

How to make coffee.—The best form in which to prepare coffee is undoubtedly the French *café au lait*—half coffee infusion and half boiling milk; but it is to

be noted that this beverage is only suitable when not too much solid food is consumed at the same time, as in the French early breakfast ; it is less well suited to the *déjeuner à la fourchette*, or to the relatively substantial British or American breakfast; because, being already to some extent charged with solid nutriment, it is a less efficient drink in the sense of food solvent. After a meal *café noir*, i.e., without milk, is to be preferred, as caffeine stimulates peptic digestion.

Dyspeptic persons, on the other hand, cannot be advised to indulge in the practice of taking coffee after dinner.

While the aroma of coffee appears to be less sensitive than that of tea, the custom—fortunately disappearing—of allowing coffee to ' stew ' for hours in urns is quite unjustifiable.

Coffee without caffeine.—With the object of supplying the means of preparing a beverage resembling ordinary coffee but without its specific action upon the nerves, several firms, particularly in Germany, are selling decaffeinised coffee. There are also species of coffee plants, mostly from Madagascar, which yield seed devoid of caffeine (Bertrand, *Bull. Sc. Pharm.*, 1902), viz., *Coffea gallienii*, *C. Bonieri* and *C. Mongeneti*, while coffee from *C. Mauritiana* is almost free from the alkaloid.

Use of chicory.—Under the name ' French coffee ' it is customary to supply a mixture containing chicory ; many persons are said to prefer this to coffee alone, but it is difficult to understand why, unless for the reason that it is, or ought to be, cheaper. Roasted chicory has a much less pleasing flavour and is devoid of caffeine. Hitherto it has been regarded as harmless,

but in recent experiments made upon cattle (J. Swintz, 'Physiol. Versuche mit der Cichorie') a very markedly unfavourable effect upon growth and development was observed when chicory was mixed with the food.

Coffee substitutes.—Besides chicory, a great number of materials have been proposed from time to time, and actually used. (Some are patented.) Such are: Roasted dates, figs, acorns, rye, maize, malt, lupins, horse chestnut, beetroot pulp and re-dried and re-roasted exhausted coffee. Schutz and Horley patent the addition to roasted coffee of half its weight of sugar, starch or carbonate of lime!

Adulteration of coffee.—The admixture of any of the preceding substances with coffee without announcement to the buyer would, of course, constitute adulteration, and some of these articles have been found mixed with coffee to the extent of 30 per cent., and even more in Berlin samples (Griebel and Bergmann, *Zeit. Unters. Nahrung. Genuss.*, 1911). An objectionable adulterant detected by these chemists was the seed of *Lathyrus sativus*, once used in Southern Europe in bread-making but found to give rise to a chronic poisoning termed lathyrism, the cause of which is unknown.

Artificial coffee berries are said to be made from one or other of the above-mentioned materials.

Glazing, effected by addition of sugar during roasting, is a common practice which is defended by some as preventing part of the loss of coffee constituents during the heating.

COCOA AND CHOCOLATE

Cocoa is obtained from the beans of *Theobroma cacao*, a tree grown in many tropical regions, notably in San Thomé, Ecuador, Trinidad, Brazil and Venezuela. The tree bears large fruits or berries enclosing from 10 to 40 seeds (or beans) in its soft pulp. After removal from the fruit, the beans are stacked and fermented, then dried; in that state they are ready for export.

The relative importance of the sources of supply of cocoa is shown from the following statistics of the production in 1907:—

Brazil	55 million lb.
San Thomé	53 " "
Ecuador	42 " "
San Domingo	22 " "
Trinidad	41 " "
Venezuela	29 " "
British West Africa	23 " "
New Grenada	10 " "
Ceylon	10 " "

Jamaica, Cuba, Haiti, Java, Fernando Po, each from 3 to 5 million lb.

Smaller crops in various other places brought up the total to 326 million lb., or in round figures nearly 150,000 tons.

In 1909 the world's output was nearly 400,000,000 lb.

Preparation.—After roasting, the beans are passed between 'kibbling' machines, which crack them so that the skin may be blown away; the pieces into which the kernel is broken constitute '*cocoa nibs*.'

For the manufacture of *chocolate*, cocoa nibs con-

taining their full quantity of fat (50 per cent. or more) are mixed with sugar and flavourings, such as vanilla, cinnamon, etc., and ground in a warm granite mill, the heat causing the fat to melt and the mass to become plastic.

As cocoa nibs, if genuine, contain too much fat for use in the preparation of breakfast cocoa, it is customary to remove a portion; the resultant product being sold under the misleading title '*cocoa essence*,' or more appropriately '*cocoa powder*.'

Composition of cocoa and cocoa products:—

	Moisture.	Fat.	Protein.	Theobromine.	Fibre.
Cocoa nibs	2 to 5	44 to 57	9 to 12	0·9 to 2·7	$2\frac{1}{2}$ to 9
„ essence	2 „ 5	27 „ 33	12 „ 15	—	
Chocolate—					
Good .	2 „ 4	22 „ 33	7 „ 11	—	—
Inferior .	2 „ 4	1 „ 33	—	—	—

Other constituents: Trace up to 0·4 per cent. caffeine; 4 to 6 per cent. cocoa-starch in genuine cocoa nibs or powder; large quantities of added starch in some brands of cocoa; cocoa-red, tannin, gums (araban, galactan, etc.), pentoses, mucilage (in shell), oxalic acid (up to 0·4 per cent.), mineral salts yielding ash 5 to 6 per cent., added sugar 40 to 60 per cent. in chocolate, and added potash—in the case of so-called soluble cocoas—up to 5 per cent., expressed as carbonate of potash.

Properties: Is cocoa a food?—Cocoa is far less nerve-exciting than either tea or coffee, and, because the natural beans enclose much fat and a fair proportion of protein, cocoa has been entered in the category of foods; in fact advertisers have proclaimed it to be

an ideal food; and so active has been the propaganda that even medical men have sometimes formed exaggerated opinions of the nutritive value of the preparation. Cocoa-butter is a food, and cocoa made with milk is nutritive—chiefly because of the milk present; but, practically speaking, cocoa beans considered apart from the fat they contain are not a food, or at any rate not an ideal food. They are scarcely better entitled to the term than is tea or coffee.

Of the supposed large proportion of protein in cocoa, 60 per cent. is unassimilable, the amount of cellulose and fibre being too large (nearly 10 per cent. in some samples) to permit of proper digestion, and of the non-protein components the fat alone is readily digestible.

However we may define a food (and there is no short definition quite free from objection), a substance which is to fulfil the duties of an aliment should at least be innocuous when consumed in more than teaspoonful doses; a man may eat a pound of bread, meat, potatoes or fruit at one time, and far from injuring himself thereby, may be actually benefited; they are true foods. But consider the possible consequences of consuming the contents of only a quarter-pound tin of cocoa in one day!

We do not eat tea leaves or coffee grounds, but because we swallow ground cocoa beans we regard them as a food.

A material of this kind which is only taken, or can only be taken, in quantities of a teaspoonful or so is more consistently described as a food adjunct.

Let us then look upon cocoa as a powder adapted to the preparation of a pleasing beverage of mildly stimulating character. We refer here to unmixed

cocoa powder. Where we employ one of those mixtures containing much foreign starch, we get, when boiling water is added, something which deviates from a true beverage and approaches to the character of a liquid pudding, for gelatinised starch cannot facilitate the assimilation of solid foods.

If again we desire a tasty confection we may select chocolate. This, too, when prepared as 'breakfast chocolate' is an inefficient solvent for other foods, since it is already charged with solids—dissolved and in suspension.

Soluble cocoas.—As 80 to 90 per cent. of the cocoa bean is insoluble in water and quickly settles to the bottom of the cup, so-called soluble cocoa is sold. The description is inexact; there are no cocoas really wholly soluble. What is done in the case of those so named is to add a certain amount of carbonate of potash, which saponifies some of the fat and combines with other constituents (tannin and oxalic acid), the result being that on the addition of boiling water a medium is formed in which the insoluble matters seem to be dissolved but are in reality merely kept longer in suspension than would otherwise be the case. Carbonate of potash and soap are not compounds which aid gastric digestion. Inasmuch, however, as only a small proportion of potash is generally used (5 per cent. of carbonate of potash, reckoned on the weight of the dry cocoa powder, appears to be a maximum), any adverse effect cannot be very large, except perhaps upon invalids and young children.

It has been suggested that in hyper-acidity alkalised cocoa might be beneficial; possibly, but hyper-acidity is far less common than the opposite condition. In

Austria and the United States the importation of alkali-treated cocoa is forbidden.

Adulteration of cocoa.—The chief modes are addition of ground cocoa husk, substitution of other fats for the natural cocoa-butter, and unduly low proportion of cocoa in the mixture as a whole.

CHAPTER XVII—Continued

ALCOHOLIC BEVERAGES

In all alcoholic beverages we find the same alcohol, chemically known as ethyl alcohol, C_2H_6O, differently flavoured and in various degrees of dilution ; in every case, too, it has been produced directly or indirectly from saccharine matter by fermentation—with or without subsequent distillation. It is true that it is mostly associated with what are called higher alcohols (because of their higher molecular weight), such as propyl, butyl and amyl alcohol, but these, except in inferior qualities of spirit, are only present in very small proportions. They are known also as fusel oil.

The various flavourings, which are far more numerous, will be referred to later.

Distilled spirits are produced from malted and unmalted grain in the United Kingdom, in great part from potatoes in Germany, maize in the United States, potatoes and rye in Russia and—apart from Cognac, which, if genuine, is wholly from the grape—from beetroot and molasses in France.

Other materials, such as fruits, are also employed in most countries.

The physiological properties of alcohol are thus

described by Dr. J. Mitchell Bruce ('Materia Medica and Therapeutics') :—

'Alcohol . . . precipitates some of the pepsin as well as some of the peptones and proteids; so far it depresses digestion. It stimulates the mucous membrane, dilating and filling the vessels with blood; excites and markedly increases the flow of gastric juice; sharpens the appetite; and renders the movements of the viscus more energetic; in these respects it greatly assists digestion. The total effect of a moderate dose of alcohol is decidedly to favour gastric digestion, especially in cases where the nerves, vessels and glands lack vigour, as in old age and chronic dyspepsia of persons weakened by acute illness, town life and anxious sedentary employments. Herein consists the value of a small amount of wine or wholesome ale taken with meat meals by such subjects.

'The danger lies in excess, which readily destroys the activity of the juice, contracts the blood vessels and sets up a secretion of alkaline mucus which greatly interferes with digestion, a common cause of acute dyspepsia.

'The action of alcohol on the gastric wall produces extensive effects of a reflex kind. The heart is stimulated by moderate doses, producing a pleasurable rise of blood pressure and a sense of power. The vessels dilate universally, filling the active organs with blood, which further increases their activity, the brain being especially excited and the skin warmed and flushed subjectively. If the dose be large, these salutary effects of alcohol as a diffusible stimulant may pass into depression;

and the sudden ingestion of a large amount of a spirit may prove rapidly fatal by shock.

'The reflex effects of alcoholic stimulants, if properly applied, add to their value at meal-times by increasing the enjoyment of eating, and thus the digestive power. . . . Alcohol is rapidly taken up by the various organs, chiefly unchanged. If taken in moderate quantity it is (1) oxidised in its passage through the tissues like carbohydrates, that is, it is a food or source of heat and energy. At the same time it produces two other equally important effects, for (2) it reduces the activity of metabolism or the oxidation of the tissues; and (3) it first stimulates and afterwards depresses the circulatory and nervous systems, quite independently of its action on tissue change.'

Alcohol utilised in the body.—A series of very interesting researches collated by Dr. M. M. Scarbrough (whose work is reviewed in the *Lancet* of 12th March, 1910) prove that moderate quantities of alcohol suitably diluted are oxidised and consumed in the system like sugar or other carbohydrate to the extent of 98 per cent., only 2 per cent. escaping unconsumed by the breath, skin, etc. It was further demonstrated that under the same conditions (i.e., suitable dilution) it does not retard digestion, that it will support life for a time when no other food can be taken, and that on substituting alcohol for an equivalent amount of fat or carbohydrate in a diet just sufficient for the needs of the body wasting does not occur.

Consequently alcohol may be regarded as fulfilling the duties of a food, although its special action upon the nervous system prevents its employment in that

capacity except in moderate quantities or exceptional circumstances.

Medical uses for alcohol.—Dr. Scarbrough believes alcohol is valuable in many conditions of malnutrition, as it does not require digestion, and is easily and readily absorbed. Further, it is one of the few foods that can be given subcutaneously. For diabetes it is of particular service in place of sugar, Neubauer having found that daily doses of 12 to 24 ounces of a wine containing 10 per cent. of alcohol effected a marked decrease in the excretion of sugar and acetone.

Strenuous muscular work, such as athletics, is best performed, however, without alcohol—doubtless by reason of the action upon the nerves.

Composition of alcoholic beverages.—In comparison with the alcohol, other constituents of alcoholic beverages are relatively unimportant; in wines we have traces of tannin, organic acids and acid salts of tartaric, malic, lactic and succinic acids, colouring matters (chlorophyll and derivatives thereof), pectin, glycerine, mineral salts and the volatile flavourings—ethereal oils, esters and aldehydes; but altogether they do not amount as a rule to more than from 1½ to 2½ per cent. Sugar is practically absent except in sweetened wines (port, sherry, champagne).

The alcohol in still French wines of good quality usually ranges from 8 to 11 per cent. absolute alcohol by volume, or 14 to 19 measures of proof spirit in 100.

In champagne the total extract ranges from 2 to 3¼ per cent. (of which a small portion is sugar), and the alcohol from 10 to 12 per cent. (absolute).

British wines, contrary to a widespread belief, are, as a rule, stronger than claret; thus E. Russell and T. R. Hodgson (*Analyst*, 1911, 60) found in ginger wine 20 to 25·6 per cent. of proof spirit ($11\frac{1}{2}$ to 14·6 per cent. of absolute alcohol by volume); the amount of sugar, too, is very large—9·6 to 29 per cent. in the same samples.

These remarks do not apply to *cider*, in which the proportion of alcohol is but little above that of beer, and the solid matters not more than 2 or 3 per cent.

In *beer* we have more of the dextrinous principles than in wines, also malt sugar; and in place of tartaric and malic acids there are present lactic and carbonic acids; further, traces of resinous matters and essential oil from the hop, as well as bitter principles of like origin. The total solid matters in beers—excepting those that are very strong—range from 2 to 6 per cent., and the alcohol from 3 to 5 per cent.; rather more in Burton and old ales.

In *distilled spirits* (whisky, brandy, rum, gin) solid matters are quite insignificant in amount. Spirits contain practically nothing but alcohol, water and flavourings.

The percentages of absolute alcohol in ordinary potable spirits are as follows:—

Whiskies . . .	50 to 60
Brandies . . .	45 „ 65
Gin	35 „ 45
Rum	35 „ 70

The flavourings of spirituous beverages.—By the aid of one of the modern 'patent' stills, spirit of any kind may be so perfectly rectified that all flavouring is

removed, the spirit losing its distinctive taste to such an extent that its origin can no longer be determined. Such a spirit is termed 'patent' or 'silent' spirit, and may be made the basis of any of the ordinary spirituous beverages by mixing with it the necessary artificial flavouring.

If, however, the spirit is distilled from a 'pot-still' or other form of still less perfect as a rectifier than the 'patent' still, most of the fusel oil (the higher alcohols propyl, butyl and amyl) is abstracted (provided the process be efficiently carried out), but sufficient flavour is left to give the resulting product a specific character that reveals its origin; that is to say, a malt spirit treated in this way will have the flavour of whisky, a wine will yield a brandy, fermented molasses will produce rum, and so on.

The natural flavourings of such liquors consist of minute proportions of the higher alcohols, combination of alcohols with acids (these are termed esters), traces of free acids, and still smaller traces of aldehydes (compounds intermediate between acids and alcohols).

The sum total of these substances is very small—say 2 to 5 parts in 1000 parts of the beverage as sold, or expressed in the usual manner, 500 to 1000 parts in 100,000 parts of the absolute alcohol contained in the liquor.

In spirits which have been mixed with the product of the 'patent' still these proportions are much lower; thus an adulterated brandy may contain only 200 instead of about 500 parts of the substances referred to (in every 100,000 parts of absolute alcohol).

FERMENTED MILKS

Koumiss, made in Tartary from mares' milk, but also prepared in other countries from cows' milk, is an acid, weakly alcoholic fluid, containing :—

Alcohol	1	to	3	per cent.
Lactic acid . . .	0·6	,,	2·5	,, ,,
Milk sugar (according to age)	nil	,,	3·0	,, ,,
Nitrogenous matters . .	1	,,	3·5	,, ,,
Fat	1	,,	2·5	,, ,,
Mineral salts . . .	0·3	,,	0·6	,, ,,

together with carbonic acid gas.

Being easily assimilated, koumiss has been recommended as a food for consumptives, and is reputed to be beneficial in increasing the weight of the patients.

Kephyr, or Kefyr, resembles the above in chemical composition, but differs in that a special ferment is used in its production. It has been employed, it is said, with good results for infant feeding ; its specific advantage lying in the semi-digested condition of the protein contained in it. No clotting can occur in the stomach.

MINERAL WATERS

Mineral waters are either natural or artificial ; the former, having a therapeutical rather than a dietetic interest, will not be considered here ; artificial mineral waters, a term inappropriately applied to such diverse and non-mineral preparations as lemonade, ginger beer and soda water (which contains no soda), are usually prepared from water charged with carbonic acid gas (carbon dioxide) with or without flavourings.

Soda water is carbon dioxide and water, that and nothing more—if we ignore incidental impurities occasionally present.

Lemonade, the factory-made article, is the same plus a little syrup, tartaric acid and oil of lemon.

Ginger beer, if not of the ' home-made ' type, is made exactly as lemonade, except that a little essence of ginger is added.

A multitude of other non-alcoholic preparations are made in a similar way.

Objectionable features of most of these drinks are :—

(1) The presence of saccharin, a coal-tar product (see article on ' Sugar '), which has an intensely sweet taste but no nutritive value. It is a drug and not a food, and one which has been forbidden in the United States except for medical purposes.

(2) The use of saponin, or ' heading ' powders containing it. Saponin being a hæmolytic poison—that is, one which destroys the red corpuscles of the blood—should be prohibited.

The reason given for the use of saccharin is that sugar is fermentable, and fermentation being undesirable in these preparations, a non-fermentable sweetener must be employed. We hold that the majority of these ' mineral waters ' are far too sweet and that saccharin is unnecessary.

The object of the addition of saponin to mineral waters and other non-alcoholic beverages is the production of a froth or ' head ' ; this ' head ' may seem desirable, but saponin is certainly not. There are sub-

stances without the toxicity of saponin that may be used, e.g., gum arabic. On the whole, however, it would be preferable to dispense with the head altogether, for it has no real merit.

Impurities.—Where cleanliness in the manufacture is not rigidly enforced, these waters may contain large numbers of bacteria and other impurities.

Price and intrinsic value.—Although the raw materials cost very little, the expenditure upon bottles—so many of which are broken or lost—and upon carriage and delivery is very heavy, so that the price charged to the public is exceedingly high in proportion to the intrinsic value of the fluid.

It must be remembered, too, that these factory-made drinks differ very greatly from the beverages they originally represented; thus, home-made lemonade contains the soluble salts and other ingredients of the fruit, but the effervescent factory-bottled article contains nothing of the lemon except a trace of essential oil.

Lemonade powder has the same drawback also.

Why not use the more wholesome home-made article prepared from fresh fruit? It is cheaper and yet better.

Fermented non-intoxicating drinks.—These are made by mixing yeast with a solution of sugar flavoured with herbs, fruits, etc., and allowing the whole to ferment in a warm place. The sugar is transformed by the yeast, more or less completely according to circumstances, into alcohol and carbonic acid gas. Home-made or ‘stone’ ginger beer is of this type.

CONDIMENTS

The chief of condiments is *common salt* (sodium chloride), which appears to be essential to digestion, for the gastric glands obtain from it—probably by interaction with acid phosphate—the hydrochloric acid needed for peptic action, thus :—

NaH_2PO_4	+	$NaCl$	=	HCl	+	Na_2HPO_4
Acid sodium phosphate		Sodium chloride		Hydrochloric acid		Neutral Sodium phosphate.

It is found in all the tissues and fluids of the body, in every food (although not in sufficient quantity), in drinking water (usually to the extent of 1 or 2 grains to the gallon) and in traces in the dust of the atmosphere. Our tissues are bathed in a weak solution of salt, the whole body containing some 300 grains (nearly $\frac{3}{4}$ oz.).

Vegetables are deficient in soda salts, hence herbivorous animals and vegetarians must add salt (sodium chloride) to their food, while the carnivora can dispense with it, for the potassium salts which are abundant in vegetables cannot replace those of soda.

The consumption of common salt, apart from that normally existing in natural food products, is estimated at 7 kilos (15·4 lb. or 246 oz.) per head per annum, which represents about 19 grammes or 300 grains daily.

This quantity is possibly in excess of our needs, but any surplus is withdrawn from the system via the kidneys, and to a very small extent by the skin.

Salt in quantity retards or prevents putrefaction and is probably the least harmful of preservatives. Introduced into the stomach, it promotes the flow of the gastric secretion. Excess, however, is prejudicial.

Salt stands alone as the only mineral substance habitually used as a condiment.

The impurities commonly occurring in commercial salt are sulphate of lime and chlorides of magnesium and calcium, the sum of which three compounds should not exceed two per cent. Arsenic is invariably present, but in too minute proportions to be harmful.

Magnesium and calcium chlorides being very deliquescent (attracting moisture from the air), the device of introducing a little phosphate of soda has been adopted in the case of certain proprietary non-caking table salts, the addition leading to an interaction whereby phosphates of lime and magnesia are formed, and these salts are not deliquescent.

Pepper.—Black pepper is the dried, unripe fruit of *Piper nigrum*, white pepper being the same fruit dried after ripening and deprived of its outer coating. The former is the stronger. Both are stomachic, stimulating and carminative, assisting digestion and useful in alleviating flatulence.

The active ingredients of pepper are essential oil, resinous principles, and the alkaloid piperine for which febrifugal properties are claimed.

Mustard.—The ground seeds of black and white mustard, *Brassica nigra* and *B. Alba* (*Sinapis nigra* and *S. Alba*) owe their activity to a volatile sulphur containing oil which is liberated on contact with water—being split off from a glucosidal compound by the action of an enzyme.

The essential oil, which has a powerful irritant action upon mucous membranes, must not be confused with the fatty, fixed oil also present.

Mustard taken internally in small quantities is

stimulant and diuretic; in large amounts it acts as an emetic.

The too frequent use of mustard at meals is undoubtedly injurious.

Vinegar, the product of the acetous fermentation of saccharine matters or of alcohol, is generally made in this country from malt; on the Continent there is a large production of wine and cider vinegars. An inferior quality of vinegar, produced from wood spirit, is also sold; it is lacking in flavour and in the extractives and salts which are invariably found in the vinegar made from malt.

'Vinegar essence' is a relatively concentrated solution of acetic acid which requires dilution with water before table use; this fact constitutes an element of danger, and several accidents have arisen through failure to add the water before consumption.

Ordinary malt vinegar contains:—

Acetic acid . . .	4	to	6	per cent.
Malt extractives . .	$1\frac{1}{2}$	,,	$2\frac{1}{2}$	,, ,,
The latter including salts .	0·25	,,	0·6	,, ,,

The balance is water.

By rendering certain foods more pleasing to the palate, vinegar may aid their digestion, but the acid of vinegar—acetic acid—has not that favourable effect upon peptic action which has been observed with lactic, tartaric and citric acids. Used in more than the quantity necessary to communicate an agreeable acidity to the food—say a salad—vinegar may seriously disturb metabolism.

Horse-radish, the root of *Cochlearia Armoracia* or *Armoracia rusticana*, belongs to the same botanical family as mustard, which it resembles in that it owes

its activity to a volatile oil containing sulphur. The two oils in question have analogous irritant properties. Horse-radish root, being very fibrous, is difficult to digest and should therefore be employed with caution.

Properties of spices.—Although introduced into foods mainly for flavouring purposes, spices have, in addition to their aromatic characters, other useful properties, being in general carminative—relieving or even preventing flatulence or intestinal pain—antiseptic and stomachic stimulants and tonics.

Such virtues are possessed for instance by :—

Cloves, the dried buds of *Eugenia caryophyllata* ;

Cinnamon, the inner bark of *Cinnamomum zeylanicum* ;

Nutmeg, the dried seed of *Myristica fragrans* ; and

Ginger, the dried and scraped root (rhizome) of *Zingiber officinale*.

CHAPTER XVIII

COOKING

A PLEASING taste and an attractive or 'appetising' appearance are by no means insignificant factors in promoting assimilation; even the robust person cannot afford to ignore them, while to others they become increasingly important the greater the deviation from a normally vigorous appetite.

These considerations, together with those of digestibility and nutritiveness, are the guiding principles of the culinary art. Their study will be beyond the scope of this work, but a few remarks upon the chemical effects of cooking may not be out of place.

Chemical effects of cooking.—Starch, the nutrient of which we habitually partake most, is very indigestible in the raw state, but by boiling, the granules are burst open and greatly distended, so that the digestive secretions act on them readily.

Sugar when boiled in the presence of acid, as in jam-making, may be converted into invert sugar, as has been explained elsewhere; in the high temperature of the oven, too, it may undergo caramelisation, but boiled with water alone, or in the absence of acids or alkalies, it undergoes but little change.

Fats also are but little affected by the heat of boiling water, or in the ordinary cooking of meat or pastry,

unless the temperature be allowed to reach a very high point, in which case decomposition will set in, a phenomenon easily detected by the pungent odour of acrolein which will be developed.

As might be expected from the great diversity and complexity of proteid substances, their behaviour under the influence of heat is far less simple than is the case with the carbohydrates and fats; many of the changes cannot be followed, but others are more clearly defined.

The results will vary according to the manner of heating, a fact very well known to the experienced cook; thus, while a gentle heat—'digestion' in the culinary sense—may break down the fibres of meat and render it easy of digestion in the alimentary sense, rapid or 'hard' boiling may have the opposite effect, the muscular tissue being so hardened as to greatly increase the work of the assimilatory organs.

Cooking, therefore, unless scientifically conducted, may actually render meats less easily digestible than if raw.

As was shown when speaking of meat extracts, albumin is coagulated by heat, and, like fibrous tissue, is not dissolved by boiling water; some peptonisation does, however, occur, with consequent solution, after long heating at not too high a temperature. The stimulant bases, purine bodies and the like, are readily dissolved by water, hot or cold.

These facts may be utilised in various ways in cooking; thus, if we wish to retain as much as possible of the nutrients in a piece of boiled meat, it should be plunged undivided into boiling water, kept at that heat for a few minutes and then stewed at a lower temperature. In this manner there is formed upon the

exterior an outer layer of coagulated matter which helps to prevent the escape of the interior juices, while the boiling point having been maintained but for a very short time, the inner parts of the joint preserve their softness. If, on the other hand, we desire to prepare a beef-tea or broth containing as much as possible of the soluble constituents of the meat, the proper course is firstly to divide the meat into very small pieces, then place it in cold water and raise the heat very gradually without allowing it to reach the boiling point, so that coagulation is prevented.

In roasting, baking and frying, changes more profound than those produced by boiling occur on the exterior of the meat, but not within, for the escaping steam protects the interior from becoming hotter than boiling water. The deeper external changes effected by roasting, etc., lead to the development of flavours which are wanting in boiled meat ; much water, too, escapes from the meat in these forms of cooking, so that the nutrients are to some extent concentrated ; in the lean of a grilled mutton chop, for instance, there may be 35 per cent. of protein, whereas before cooking it contained but 20 per cent. or thereabout. Except for the escape of fat, very little loss of nutrient matters takes place in roasting, baking or frying, so that these processes are really more economical than that of boiling, in addition to their superiority from the point of view of palatability.

CHAPTER XIX

SEASONS FOR FOODS

COLD storage, the facilities afforded by rapid transit and the developments of modern agriculture have combined to so extend the periods within which fresh foods are obtainable that many, perhaps the majority, can now be procured at almost any time of the year, so that the following tables can only be taken to indicate the more or less natural seasons :—

Meats—

Beef and mutton—throughout the year ; best period Oct. to March.

Veal and lamb—Spring and summer ; best period, summer.

Pork—Sept. to April ; best period, Nov. to Feb.

Poultry, Game, etc.—

In general, winter is the best season, but for young birds (chickens and ducklings), also guinea-fowl, the best periods are spring and summer.

Blackcock and grouse	Aug. to Nov.	at their best	Sept. to Oct.
Hares . . .	Sept. ,, March	,,	Oct.
Partridges, quail .	Sept. ,, Feb.	,,	,,
Ptarmigan . .	Sept. ,, April	,,	Sept.
Venison . . .	Sept. ,, Jan.	,,	Sept. to Oct.
Wild ducks . .	Oct. ,, Dec.	,,	Nov. ,, Dec.

Pheasants, plover, snipe, teal, widgeon, woodcock—Oct. to Feb. ; at their best generally Oct. to Dec.

Fish, crustacea, etc.—

Bream, brill (nearly all the year); cockles, crayfish, halibut, ling, lobster, mackerel (nearly all the year); red mullet, plaice, prawns, shrimps, soles, turbot, whiting (practically all the year round).

Barbel, bloaters, carp, cod, crabs, haddocks, herrings, mussels, oysters, pike, skate, smelts, sprats—Autumn to spring

Perch	Dec.	to	March
Scallops	Jan.	,,	June
Eels	June	,,	March
Lampreys	Jan.	,,	March
Salmon, shad, sturgeon, trout .	April	,,	Aug.
Grey mullet	July	,,	Oct.
Whitebait	Jan.	,,	Sept.

Vegetables—

Beetroot, broccoli (various kinds), carrots, potatoes—all the year; best season, autumn.

Cabbage . .	all the year; best season	Spring & summer.
Spinach, watercress .	,, ,, ,, ,,	Summer.
Onions . . .	,, ,, ,, ,,	Summer & autumn.

Summer season:

French beans . .	May	to	Oct.
Lettuces . .	,,	,,	Nov.
Potatoes, new .	,,	,,	Aug.
Radishes . .	,,	,,	Sept.
Peas . . .	June	,,	Sept.
Tomatoes . .	,,	,,	Dec.
Vegetable marrow .	,,	,,	Oct.
Broad beans . .	July	,,	Aug.
Runner beans . .	,,	,,	Oct.

Spring season:

Asparagus . .	Jan.	,,	July	best season	April to May
Seakale . . .	,,	,,	May	,,	Feb. to Mar.

Winter season:				best	
Endive	Sept.	to	March	season	Oct. to Nov.
Red cabbage	Oct.	,,	Feb.	,,	Nov. ,, Dec.
Celery	,,	,,	March	,,	,, ,,
Leeks	,,	,,	May	,,	Oct. ,, Nov.
Parsnips	,,	,,	April	,,	Winter
Savoys	,,	,,	March	,,	Nov. to Jan.
Sprouts	Nov.	,,	,,	,,	Dec., Jan.

Fruits, nuts—

Green gooseberries	May	,,	July
Cherries	June	,,	Aug.
Strawberries, apricots	,,	,,	Sept.
Melons	,,	,,	Nov.
Currants, gooseberries (ripe)	July	,,	Sept.
Greengages	Aug.	,,	,,
Plums	,,	,,	Oct.
Pineapples	,,	,,	Nov.
Bullaces, damsons, figs, nectarines, peaches, quinces	Sept.	,,	Oct.
English hot-house grapes, English pineapples	,,	,,	Dec.
Apples, pears	Oct.	,,	March
Medlars	,,	,,	Jan.
Grapes (foreign), oranges, lemons, almonds, dried fruits	all the year		

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